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ABSTRACT

A study investigated what was possible in terms of student learning when a conceptual change model of teaching science and a writers' workshop model of teaching writing were used consistently across time. Similarities and contrasts in the curriculum, learning communities, and teachers' roles when the two instructional models were used (by two different teachers) in a fifth-grade classroom of 22 students were analyzed. Results revealed five broad similarities in the science and writers' workshop curriculum and learning community. The teacher: (1) develops curriculum strands that are interwoven over time; (2) uses writing tasks as learning tools; (3) connects writing tasks to a wider range of learning activities; (4) scaffolds student thinking and participation in the learning community; and (5) creates writing and other tasks that are congruent with the norms of interaction in a learning community. Seven areas of contrast in the teachers' roles in structuring and carrying out writing activities were found: (1) framing writing tasks to achieve subject matter goals; (2) defining purposes for writing; (3) using writing to meet individual learning needs; (4) choice in writing tasks; (5) developing ownership; (6) audience; and (7) response. Findings suggest that there are ways in which teaching writing and teaching science are distinctive activities with distinctive subject matter goals that require different approaches and different teacher roles, and that the two instructional models are complementary and enable teachers to work toward fostering a learning centered classroom. Six tables of data and two figures are included. (Contains 34 references.) (Author/RS)

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Elementary Subjects Center
Series No. 94

SIMILARITIES AND CONTRASTS BETWEEN WRITING DURING A WRITERS' WORKSHOP AND WRITING IN SCIENCE: EXAMINING THE TEACHER'S ROLE

Cheryl L. Rosaen and Kathleen J. Roth

Center for the Learning and Teaching of Elementary Subjects

Institute for Research on Teaching
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The **Center for the Learning and Teaching of Elementary Subjects** was awarded to Michigan State University in 1987 after a nationwide competition. Funded by the Office of Educational Research and Improvement, U.S. Department of Education, the Elementary Subjects Center is a major project housed in the Institute for Research on Teaching (IRT). The program focuses on conceptual understanding, higher order thinking, and problem solving in elementary school teaching of mathematics, science, social studies, literature, and the arts. Center researchers are identifying exemplary curriculum, instruction, and evaluation practices in the teaching of these school subjects; studying these practices to build new hypotheses about how the effectiveness of elementary schools can be improved; testing these hypotheses through school-based research; and making specific recommendations for the improvement of school policies, instructional materials, assessment procedures, and teaching practices. Research questions include, What content should be taught when teaching these subjects for understanding and use of knowledge? How do teachers concentrate their teaching to use their limited resources best? and In what ways is good teaching subject matter-specific?

The work is designed to unfold in three phases, beginning with literature review and interview studies designed to elicit and synthesize the points of view of various stakeholders (representatives of the underlying academic disciplines, intellectual leaders and organizations concerned with curriculum and instruction in school subjects, classroom teachers, state- and district-level policymakers) concerning ideal curriculum, instruction, and evaluation practices in these five content areas at the elementary level. Phase II involves interview and observation methods designed to describe current practice, and in particular, best practice as observed in the classrooms of teachers believed to be outstanding. Phase II also involves analysis of curricula (both widely used curriculum series and distinctive curricula developed with special emphasis on conceptual understanding and higher order applications), as another approach to gathering information about current practices. In Phase III, models of ideal practice will be developed, based on what has been learned and synthesized from the first two phases, and will be tested through classroom intervention studies.

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Abstract

The authors took on a teacher-researcher role in a fifth-grade classroom as part of their collaborative work with a group of educators. While Rosaen taught and studied the establishment of a writers' workshop approach to teaching writing, Roth explored the role that writing could play in her teaching of science to the same group of students. They investigated what is possible in terms of student learning when a conceptual change model of teaching science and a writers' workshop model of teaching writing are used consistently across time. In particular, they analyzed similarities and contrasts in the curriculum, learning communities, and teachers' roles when the two instructional models are used.

The study revealed five broad similarities in the science and writers' workshop curriculum and learning community: The teacher (a) develops curriculum strands that are interwoven over time, and include a focus on learning community; (b) uses writing tasks as learning tools; (c) connects writing tasks to a wider range of learning activities; (d) scaffolds student thinking and participation in the learning community; and (e) creates writing and other tasks that are congruent with the norms of interaction in a learning community. Excerpts from science and writers' workshop lessons are discussed to illustrate the similarities.

Seven areas of contrast in the teachers' roles in structuring and carrying out writing activities were found. These areas include (a) framing writing tasks to achieve subject matter goals, (b) defining purposes for writing, (c) using writing to meet individual learning needs, (d) choice in writing tasks, (e) developing ownership, (f) audience, and (g) response. Rosaen illustrates her role in these areas with a case description of how she supported two students in learning to write. Roth discusses examples of her interactions with students during a photosynthesis unit to describe her role as teacher in science and how that connects to her use of writing to support students' science learning.

The study provides insights about the ways in which instruction across subject matters can be integrated and coherent without simply asserting that teaching is a generic activity--that there is one instructional framework that will work for any subject area. This study suggests that there are ways in which teaching writing and teaching science are distinctive activities with distinctive subject matter goals that require different approaches and different teacher roles. Descriptions of the two instructional models--a conceptual change model for teaching science and a writers' workshop model for teaching writing--provide different images of how teachers can create classrooms where both students and teachers are highly involved in the teaching and learning process. They illustrate ways teachers can think carefully about the unique kinds of teacher input that are needed in relation to subject matter goals and how writing plays a role in students' learning. The authors also show how the two models are complementary and enable teachers to work toward fostering a learning centered classroom.

SIMILARITIES AND CONTRASTS BETWEEN WRITING DURING A WRITERS' WORKSHOP AND WRITING IN SCIENCE: EXAMINING THE TEACHER'S ROLE

Cheryl L. Rosaen and Kathleen J. Roth[1]

Investigating Writing in Science and Writers' Workshop

> Children, too, can learn to think on paper. But the strategies for thinking on paper are very different from the strategies for producing clear, logical, tightly focused compositions. It's important, therefore, that we teachers learn to defer some concerns until late in the composing process, when the goal shifts from thinking on paper to producing an organized composition. (Calkins, 1991, p. 67)

Working toward the dual goals of helping children to "think on paper" as well as to produce good writing is a complex curriculum and instructional challenge that classroom teachers face daily. We experienced this challenge firsthand when we took on the teacher-researcher role in a fifth-grade classroom as part of our collaborative work with a group of educators. While Rosaen taught and studied the establishment of a writers' workshop approach to teaching writing, Roth explored the role that writing could play in her teaching of science to the same group of students. We investigated what is possible in terms of student learning when a conceptual change model of teaching science (Hewson & Hewson, 1984; Johansson, Marton & Svensson, 1985; Posner, Strike, Hewson & Gertzog, 1982; West & Pines, 1985) and a writers' workshop model of teaching writing (Atwell, 1987; Calkins, 1986, 1991; Graves, 1983) are used consistently across time.

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[1] Cheryl L. Rosaen, assistant professor, and Kathleen J. Roth, associate professor of teacher education at Michigan State University, are senior researchers with the Center for the Learning and Teaching of Elementary Subjects, working from 1989-1992 on the Literacy in Science and Social Studies (LISSS) Project at an MSU professional development school. The authors would like to acknowledge the many contributions of Barbara Lindquist, a fifth-grade teacher and LISSS Project participant, who shared her classroom with them to enable coteaching and coresearching across the school year, and the many hours spent discussing student progress, data analysis, and other ideas that contributed to writing this paper. The authors also worked closely from 1989-92 with a group of teacher-researchers in the LISSS Project to improve and study their practice. They would like to acknowledge joint contributions of all project participants in data collection and analysis and in developing the ideas regarding learning community and teaching for understanding that are discussed in this report. Additional project participants are Corinna Hasbach, Constanza Hazelwood, and Kathleen Peasley (research assistants); and Elaine Hoekwater (fifth-grade teacher) and Carol Ligett (third-grade teacher). Hazelwood and Peasley assisted with field notes, audiotaping, and interviewing. Lindquist and Rosaen were responsible for coteaching writing to two classes of fifth graders while conducting research on their teaching and their students' learning. Roth taught science across the fall to one class of fifth graders while Hazelwood and Lindquist assisted with researching her teaching and the students' learning. Other project participants taught science and social studies and conducted research on teaching and learning in different collaborative arrangements.

Through this inquiry we hoped to learn more about the role writing could play in students' learning within and across subject matter areas. We also wanted to describe and understand better the similarities and contrasts in the writing students engaged in throughout the science and writing curriculum as they participated in the learning community and how our roles as teachers evolved. We were intrigued with the similarities and differences in our roles as we supported students in learning to write and writing to learn science. Were they important and helpful to students? Or were they simply variations in teacher "style" with little educational significance?

The report analyzes both the similarities and differences in our curriculum, learning communities, and roles. We discuss the struggles we each faced in defining an appropriate teacher role as we supported students in learning to write and writing to learn science. Our study suggests that there are ways in which teaching writing and teaching science are distinctive activities that require different approaches and different teacher roles. It also suggests that, in our teaching, there were important curricular and learning community similarities that brought coherence to our students' learning within and across the two subject matter areas. We reflect on how similarities and differences in our approaches might contribute to students' understanding of learning to write and writing to learn.

Listening to Students and Developing Our Research Focus

Listening to our students helped us gain insights into the kinds of connections they were making about writing in different subject matter areas as they were taught by different teacher-researchers in our group. For example, Maria and

Sarah[2] pointed out what they perceived to be some key contrasts as they discussed writing in social studies, science, and writers' workshop (4/16/91):

Maria: Well actually I pretended that I was writing to a scientist and I knew him really well and like . . . I would pretend I was the scientist. Okay, I was the girl that was writing to the scientist and I was the scientist and I would respond back with the answer I found in the book. I would go out and research it.

Hazelwood: That's neat. And what kinds of questions did you ask?

Maria: Well, I was asking about what I didn't understand in class, like about photosynthesis and different things, like, why does, I don't know, I forgot some of the questions.

Sarah: Yeah, and like, in writing workshop, it's easy to express your feelings but it's not so easy in social studies and in math to do that.

Hazelwood: I can understand a little bit in math, but social studies seems to be (inaudible).

Sarah: Well, also social studies, social studies it gives you a topic to write on, a certain topic that you have to . . .

Maria: . . . to study about.

Sarah: Yeah.

Maria: But like in writing workshop, we can think of different things.

Sarah: Yeah, like in writing workshop, if we wanted to write about teen romance, that's up to us. Mrs. Lindquist doesn't care what topic we write on. That's up to us 'cause we're the author. But in social studies, they say, okay . . .

Maria: You've got to write about Harriet Tubman . . .

Sarah: . . . we're going to write about the Civil War.

Maria: Or you have to find out about her or you have to research on her, you have to do this colony, you have to find out what they wore or what they ate, what they, what their hobbies were . . .

Sarah: . . . what religion . . .

Maria: . . . or how was the land. And in writing workshop, we have our own topics.

Sarah: We get to choose a topic we're interested in.

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[2] Pseudonyms are used for all students.

Maria: And we, we make it up.

Sarah: If we're not interested in colonization and we don't want to write on it . . .

Maria: . . . we don't have to.

Sarah: We don't have to 'cause we're the author.

Maria: But in social studies we do. . . . Unless you take it beyond yourself and do what you want to do, like I did in science. I took it beyond myself . . .

We were intrigued by the way Maria and Sarah perceived themselves to be authors in writers' workshop and we noticed that they attributed their perceptions to being able to choose their own topics. In science, Maria chose to extend her learning outside the classroom through her writing to an imaginary scientist: "I took it beyond myself . . ." She acknowledged that she could have pursued a similar use of writing in her social studies learning, but both she and Sarah indicated that interest played an important part in their decisions not to write about social studies topics outside of social studies class:

Maria: I could think of something with social studies. I could do like the same thing. I could do what I did with the scientist, but it would be with the colonial times . . .

Sarah: Like pretend you're . . .

Maria: Like Harriet Tubman, how was your life in these days. And I could go out and research, well, I'm talking, I don't know, it's just, I would never do that.

Sarah: It's not a topic we're interested in. We could.

Maria: But we, I would, I could do it, but I just, I haven't got around to it. I'm just too interested in the writing workshop.

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Sarah: Like, if we were to do a play on the past, that would be interesting. We'd research it and get it in our heads but it would be fun too, because you could like make props and stuff and you'd still learn it. But in writing workshop, we get to do that, we can like make something, like a project that goes along with a piece of writing, but we get to choose what we want to make it on. And in social studies, we don't get that chance.

Hazelwood: So the main issue for you is not being able to choose what you want to talk about?

Maria: Yeah . . .

Study of our students' learning has convinced us that they experienced significant growth in writing and in their understandings of science during our year as teacher-researchers and that writing played a key role (Rosaen with Hazelwood, in press; Rosaen & Lindquist, 1992; Rosaen, Lindquist, Peasley & Hazelwood, 1992; Roth, 1992; Roth, Peasley & Hazelwood, 1992). We had each defined and used writing differently in science and writers' workshop, and wanted to understand what the key differences were. Comments like Maria's and Sarah's prompted us to take a closer look at the instructional models on which our teaching was based to understand better how we supported students in learning to write and in using writing to support their learning in science. They also raised dilemmas for us to consider: Should students' choice of topic, form, and pace of writing in writers' workshop be extended to science class? Was the writing in science too structured? What are the learning benefits and problems when teachers share control of writing choices with their students?

The Role of Writing in Two Instructional Models

A Conceptual Change Model

Roth used a conceptual change model in her science instruction. When science learning is viewed as a process of conceptual change, learners are seen as entering instruction holding a wealth of ideas about scientific phenomena that contrast in multiple ways with accepted scientific explanations. To support students in changing these conceptions to more productive and useful scientific conceptions, instruction needs to engage students in scientific inquiry that takes their ideas seriously and supports them in revising and reconstructing their explanations (Hewson & Hewson, 1984; Johansson, Marton & Svensson, 1985; Posner, Strike, Hewson & Gertzog, 1982; West & Pines, 1985). Goals in this instructional model include helping students to understand the nature of scientific inquiry and knowledge growth, to develop connected and useful understandings of science concepts, and to develop dispositions to reflect and act on their emerging scientific knowledge and questions. A teacher might begin by establishing a problem such as: How does light help us see? Why are summers hot and winters cold? How do plants get their food? By eliciting students' ideas about the problem, by challenging students' personal theories, and by encouraging debate and a search for evidence to support differing views, teachers try to engage students in genuine involvement with a problem. This results in an array of wondering, questioning, and challenging of ideas and creates "cognitive conflict" (Piaget, 1969) and puzzlement.

Scientific concepts (e.g., about photosynthesis, adaptations) are presented in ways that support students in contrasting them with their own ideas and in using the new ideas repeatedly to explain a variety of real-world phenomena with which students are familiar. As students work with these new ideas over time and in multiple contexts, the teacher scaffolds their efforts with gentle coaching of scientific thinking. Dual goals are for students to use new ideas and to connect new ideas to other concepts and to understand the nature of science--how scientists use evidence and collaborative work to make sense of the world. The emphasis is on personal sense making and growth in understanding of one's world, not on acceptance and memorization of the experts' answers. Writing can serve as a valuable tool in supporting the conceptual change process, to support thinking and sense making (Roth, 1992), and to get students "thinking on paper" (Calkins, 1991).

A Writers' Workshop Model

A different instructional model, a writers' workshop, is prevalent in the writing literature (e.g., Atwell, 1987; Calkins, 1986, 1991; Graves, 1983). Rosaen used this model to guide her teaching of writing. The writing teacher's responsibility is to create a structure and social context within which students can write on a regular basis, share their writing with others for the purposes of celebrating finished pieces or getting feedback and assistance in making revisions. In this context, teachers need to support students in using writing to develop (a) personal knowledge (of self and one's relationship to others); (b) social knowledge (of others, of contexts in which readers may interpret writing, of audience); and (c) knowledge and language of texts (Probst, 1990). They also need to help students develop strategic control over making the decisions associated with creating a piece of writing for a particular audience, and foster in students the disposition to write. Teacher support comes in the form of helping students learn about ways to manage the writing process and to improve the texts they create, mainly through writing conferences, sharing sessions and mini-lessons. It is further advised that students will develop ownership of their writing only if they can experience making the same kinds of decisions that writers make, including choosing their own writing topics, purposes, forms, audience and time frames for generating and publishing pieces (Moffett, 1979). In a workshop model, writers learn about, practice, and perfect the craft of writing by exercising a great deal of control over a range of writing decisions.

Over the past decade, writing workshop teachers and researchers have concentrated on finding ways to support students in using a variety of written forms (e.g., journal writing, personal narratives, fiction writing, poetry, biographies, memoirs, letters) for a variety of purposes. Topics for students' writing typically came from their personal experiences. Advice in the writing literature focused only occasionally on ways teachers can support various kinds of writing, with perhaps one chapter at the end addressing ways to support students in writing about subject matter content, but almost as an afterthought (Calkins, Chapter 23, 1983, Chapters 25, 1986).

As teachers created language-rich environments in which students developed ownership of writing topics, forms, audiences and purposes, they began to learn from their students that expressive, transactional, and poetic modes of writing

(Britton, Burgess, Martin, Mcleod & Rosen, 1975) are rich resources for children to use when they are developing personally meaningful topics to write about in any form. For example, transactional writing is used to get things done or to inform people. It is a way to record facts, exchange opinions, explain and explore ideas, or construct theories. Expressive writing is close to the self, revealing the speaker and his or her relationship with a reader, and assumes the reader shares much of the writer's context. Poetic writing makes an object out of language by using language as an art medium. These modes of writing may take many different forms and the same form may be used for transactional, expressive or poetic purposes. Teachers and researchers have also learned that students are passionately interested in exploring and sometimes writing about topics that fit within the boundaries of school subjects such as science, social studies, and mathematics (Calkins, 1983, 1991; Graves, 1989; Rowland, 1986).

Emerging Issues and Research Questions

New Possibilities for Content Area Writing

These recent years of learning from children in writing workshops have sparked a renewed interest in "writing across the curriculum," not unlike the interest that was shown in the late 1970s and early 1980s. During that time period, some publications offered broad guidelines for creating content area writing projects while others contained lists of interesting writing activities that teachers could plug into content area units (e.g., Mayer, Lester & Pradl, 1983; National Council of Teachers of English [NCTE], 1986; Tchudi & Tchudi, 1983). But writing teachers are wiser now and know a great deal more about the kinds of responsibilities students are able to manage and the kinds of learning communities that support genuine inquiry into personally meaningful and authentic problems (Calkins, 1991; Graves, 1989). This new learning leads to renewed consideration of the issue of what meaningful content area writing might look like (Rosaen, 1990). How can teachers connect writing goals to other content area goals? To what extent can or should content area writing allow for the full range of decisions authors make? What topics, forms, and writing purposes are most beneficial and why? Who should be the primary audience for students' content area writing? What should be the focus of the teacher's response? To what extent is a writers' workshop model appropriate for supporting students in using writing to learn in other content areas?

The Social Context Supports Learning

The importance of the social context in supporting the learning process in all subject matter areas has also become better understood in recent years (Featherstone, 1990; Hill & Hill, 1990; Marshall, 1990; Shannon, 1989). Our LISSS group has spent a great deal of time and effort trying to articulate the qualities required in a learning community in which learning is the primary focus (Rosaen with Hazelwood, in press; Rosaen, Lindquist, Peasley & Hazelwood, 1992; Roth, 1992; Roth, Peasley & Hazelwood, 1992). As we taught, researched our teaching, and reflected across the year, we revised our ideas several times, each time striving for more clarity. Table 1 summarizes our current thinking and reflects the qualities we have come to value in our learning community. For example, the qualities of caring, respect, trust, and appreciation of diversity are part of a classroom culture that supports genuine inquiry. When students have shared goals and work collaboratively on joint problems of mutual interest, genuine inquiry can take place.

Students need to develop personal qualities to become full participants in a learning community, such as having personally meaningful learning as a commitment and goal, and the desire to go on learning. Students must also appreciate the value in both the process and products in learning. Academic, social and personal knowledge is constructed socially. Expertise comes from multiple sources, and use of evidence and shared expertise from within and outside the learning community is common. All voices in the learning community are heard and valued.

Ideas are publicly shared and explored with the expectation that revision of ideas is a natural and valued part of learning. The teacher's role in a learning community is one of a collaborative learner as well as instructional leader who carefully develops curriculum and fosters a collaborative culture.

These emerging ideas led us to ask several questions about the relationship between the writing in which our students engaged and the learning community in which they participated. How can writing be an integral and vital part of the overall learning process? How can writing help students learn to participate in a community of learners? How can writing tasks be structured so they are congruent with the norms of interaction in the learning community?

Overview of the Paper

We discuss our methodology below before discussing what we learned from our comparison of how we used writing instructionally in science and writers' workshop. We describe similarities in our curriculum and learning community and illustrate these similarities with excerpts from science and writers' workshop lessons. Then we discuss differences in the way we carried out our roles in relation to writing as we supported students' learning. Rosaen uses a case description of two students' participation in writers' workshop to illustrate her role in supporting their learning to write. Using examples of her interactions with students during a photosynthesis unit, Roth discusses her role as science teacher and how that connects to the use of writing to support students' science learning. We conclude with a section in which we consider the extent to which writing can or should be taught using the same instructional model regardless of the academic and social purposes it serves. We suggest that learning to write requires a different range of experiences than learning science, and that students can benefit from different kinds of writing experiences, depending on the learning purposes.

Table 1
Learning Community Qualities

<table>
<tr>
<td>The classroom culture supports collaborative inquiry:
*celebration of learning
*celebration and appreciation of diversity
*caring
*trust
*respect
*helping and being helped
*positive interdependence
*inquiry
*a relation of persons, not just of roles or ranks</td>
<td>The group has collaborative responsibilities
*collaboration on joint problems and questions of mutual interest
*shared goals
*shared responsibility for learning of all
*shared responsibility for curriculum construction</td>
</tr>
<tr>
<td>Individuals are personally involved in and committed to learning
*personally meaningful learning as a goal
*personal and active involvement in meaningful and authentic problems (talk, write, do, inquire)
*ownership, commitment to learning for self and others
*desire to go on learning
*value both process and products in learning</td>
<td>The teacher facilitates and participates in the culture of collaborative inquiry
*pursues genuine, meaningful, and authentic problems with students
*fosters collaborative classroom culture
*shares control over curriculum with students
*has commitment to access to knowledge for all students
*values and hears all student voices
*participates in learning community as co-constructor (not dispenser) of knowledge
*reflects carefully and regularly about curriculum development and student learning
*encourages and supports development of personal qualities in each learner</td>
</tr>
<tr>
<td colspan="2">Knowledge is socially constructed
*knowledge is personal, social, and academic
*strategic awareness and use of skills
*inquiry, asking questions
*expertise comes from multiple sources, including students' personal histories
*use of evidence, shared expertise as authority for knowing
*rational, narrative, and aesthetic ways of knowing are all valid and ways to integrate different ways of knowing are sought
*multiple connections within and across subject matter areas are explored
*valuing and respect for others' ideas are key aspects of knowledge construction
*public exploration sharing and revision of ideas
*all voices are important and heard</td>
</tr>
</table>

The Study: Research Questions, Methods, and Analysis

Research Questions

To pursue issues about writing in relation to the instructional models we used and our roles in the learning community, we developed research questions around three broad topics:

Curriculum and knowledge construction:

a. How is the curriculum selected, organized and sequenced? To what extent does the curriculum support social construction of academic, social, and personal knowledge?
b. What kinds of writing are students engaged in? For what purposes? Who is the primary audience?
c. How are writing tasks connected to broad instructional goals?

The learning community:

a. To what extent does writing enhance and support a culture of collaborative inquiry?
b. To what extent do writing tasks support students in being personally involved in and committed to learning?
c. To what extent do writing tasks require and support collaborative group responsibilities?

The teacher's role in relation to writing tasks:

a. To what extent is control over writing tasks shared with students?
b. How does the teacher support students in learning to write? In writing to learn?
c. What is the nature of the teacher's response to writing? To what extent are other members of the learning community involved in responding to writing?

Teacher-Researcher Roles

Three years ago we began working in a project called Literacy in Science and Social Studies that included ourselves, three research assistants, and three classroom teachers. In the larger project, we explored ways to teach for understanding in science and social studies, with an emphasis on studying ways in which discourse and writing can be used effectively to promote understanding for all students. In the second year of the project, the group participants took on what we call a teacher-researcher role to learn new ways to study students' thinking in a classroom setting and to study our own teaching practice. In Lindquist's classroom, Roth taught science across the fall while Lindquist and Hazelwood assisted in data collection and reflection on Roth's teaching. Rosaen and Lindquist coplanned and cotaught a writers' workshop across the year and shared the teacher-researcher role, with research assistance from Hazelwood and Peasley.

The Students

The 22 fifth-grade students in this classroom lived in a community that was changing in relation to the growth of an adjacent midsize city. Starting out as a predominantly rural, blue-collar community, it was slowly becoming more of a suburb to the city. New subdivisions were being built that attracted more professional and paraprofessional families. While most of the parents of the students in Lindquist's class had not attended college, two parents were professionals. This elementary school is considered to have the highest number of at-risk students of the five elementary schools in the district. Many students in the school live in a neighboring trailer park and are living on low family incomes.

The 22 students included one mainstreamed special education student, four older students who had repeated a grade, two students pulled out for speech therapy, and a number of students who had been on the Chapter 1 reading-resource teacher's load (although only one was seeing the teacher at the time of the study). While the students represented the usual range of academic abilities, Lindquist noted that this class had lower achievement test and IQ scores than previous classes. Racially, the class reflected the community composition: 17 Caucasian students, 1 African-American student, 3 Hispanic students, and 1 student of Native-American descent.

Target Students

Although all 22 students were studied during whole-class discussion and writing activities in both science and writers' workshop, target groups of students were the focus of study during small-group discussions and activities. In science, groups were chosen on the basis of where students chose to sit on the first day of school (one group of four girls and one group of four boys). In November the groups were changed and two new target groups were chosen, each of which had at least two students who were in the original groups; each group included two girls and two boys. In writers' workshop, nine target students in this class were chosen toward the end of the year for more intensive study (six females and three males) to represent a range of abilities, interest in writing, and participation in the classroom. Both science and writers' workshop target students represent a range of abilities, including students receiving speech therapy and Chapter 1 reading assistance and students who were more successful in their academic studies.

Our choice of target students in each subject area resulted in some overlap of target students (three). Since we were interested in tracking and comparing *our roles* in supporting students' learning in science and writing, we were more concerned that we both taught the same group of students, and that we were consistent in examining how each of our roles unfolded, than that we both studied an identical set of target students. Consequently, the illustrations in this report often describe our interactions with different students. This has allowed us to represent a broader range of students and give the flavor of what was typical of our roles in both science and writers' workshop.

Data Sources

Each science lesson across a four-month period was tape-recorded. Two tape recorders were used, with each one placed in the midst of a target group. During the photosynthesis unit, daily lessons were also videotaped. During the whole-class discussions, one camera focused on the class as a whole while the other camera focused on one of the target groups. During group work, the two cameras focused on the two target groups. Field notes were taken by Lindquist and/or Hazelwood for most lessons.

In writers' workshop, classroom lessons, group work, and writing conferences were documented with field notes, audiotapes, and videotapes across the year. All whole-class lessons were audiotaped from September through February. Whole-group lessons were both audiotaped and videotaped March through May. During individual work time, one audio recorder was placed at different four-desk clusters to capture verbal interaction. Rosaen carried an audio recorder with her whenever she worked individually with students. Large-group and small-group sharing sessions were either audiotaped or videotaped.

All student writing in science was collected across the four months. This included journals, class charts, and writing in the Food for Plants II (Roth, 1988) text/workbook, posttests for the adaptations/scientific inquiry unit, and pretests and postests for the photosynthesis unit. Teacher reflections on the teaching and learning process were captured in a teacher journal and in audio recordings of postlesson conversations with Lindquist, Hazelwood, classroom visitors, and other LISSS Project participants. In addition, teacher reflections and insights were captured in the teacher-written reports about each student sent to parents at report card time. Roth's planning was documented in her written plans as well as audiotaped planning sessions with other LISSS participants.

In writers' workshop, all students' written work was collected. This included journals, writing projects, and students' written reflections on their own writing progress. Rosaen and Lindquist audiotaped their planning sessions across the year and saved all written documents associated with planning (e.g., planning notes, schedules, calendars, and resource lists). Informal planning decisions made by the team during class were captured by the tape recorder that Rosaen carried with her.

Interviews with the students in the science target groups were conducted in the middle of the fall term (October) and at the end of the school year (May). These in-depth interviews probed students' understanding of the science concepts they were studying, their perceptions of science and scientists, and the roles that writing and classroom discourse played in their learning. All students participated in mini-interviews at the end of the photosynthesis unit (December). These mini-interviews probed students' understanding of photosynthesis-related concepts.

Six of the nine target students in writers' workshop were interviewed individually at the end of the year. Five of the nine target students participated in a group interview. Many students (including those who were not identified as target students) were interviewed informally as part of ongoing instruction and data collection throughout the year. All interviews were designed to learn more about how students made sense of the literacy learning experiences in writers' workshop, their own perceptions of the writing process and writing strategies, and how they perceived these experiences to be related (or not) to learning experiences in science and social studies.

Data Analysis

Our initial data analysis was aimed at understanding three main aspects of teaching and learning in both science and writers' workshop: (a) the intended curriculum; (b) the enacted curriculum, including the subject matter content and the development of the learning community; and (c) individual meaning constructed by students. As we pursued our questions about the similarities and contrasts between writing in each subject area, we developed additional frameworks for analysis to facilitate the comparison.

Data analysis in science. Each writing activity used across the four-month period was analyzed first from the teacher's perspective: What were the functions that the teacher intended the writing to serve? How did the writing fit in with other activities and with classroom discourse? Two unit calendars were constructed from this analysis; each unit calendar showed the nature of writing in each lesson, the relationship of that writing to ongoing conceptual development, and the purposes of the writing as intended by the teacher.

Each student's writing in science was analyzed chronologically: What did the writing reveal about the student's understanding of the science concepts being studied or about the student's developing understanding of the nature of science and scientists' work? What did the writing reveal about student thinking? What purposes did the writing appear to serve for the student? Analysis charts were developed to trace student thinking revealed through the writing and to describe the purposes of the writing from the students' perspectives.

The relationship between the writing in science and the classroom discourse was analyzed through verbatim analyses of whole-group and small-group lessons. Nine lessons were selected for focus that included both whole-group and small-group interactions. The lessons were selected to represent different points in time, a variety of activity modes, and a variety of purposes for the writing tasks. In addition, they were lessons of reasonable technical quality so that the verbatim transcripts could be made. The lessons were analyzed in terms of the presence or absence of qualities of the learning community that Roth was trying to facilitate (see Roth, 1992 for a list of initial categories used). These categories were later revised to include those described in Table 1 for the purposes of comparing the qualities of the learning community in writers' workshop with the science learning community.

The lessons were also used to analyze the relationship between students' writing and their talk during large and small-group discussions. How did the teacher's purposes for writing and for class talk compare/contrast? How did the students' purposes for writing and for class talk compare/contrast? Did the students' writing play a role in their contributions in class discussions? How did the class discussions and small-group interactions influence student's writing? Finally, the lessons were analyzed in relation to the roles the teacher played in supporting students' writing to learn science. The conceptual change model was used as a framework for analysis of the role writing activities played in supporting students' learning (e.g., establish a problem, elicit ideas, challenge thinking, scaffold students' efforts to make sense of new ideas by using them in multiple contexts) to compare the teacher's intentions with the experienced curriculum.

Data analysis in writers' workshop. A chronological summary was constructed of the intended curriculum across the year. Seven instructional units were outlined and daily lessons were summarized. This curriculum overview was used as a tool in tracing students' development over time, as a way to compare the intended and experienced curriculum, and as a way to locate in real time what was occurring in the learning community when hypotheses about a particular learner's development were investigated.

Detailed notes describing the learning community were developed that focused on the nature of language used by teachers and students, the overall atmosphere in the classroom, and the nature and level of participation. Using field notes, audiotapes, videotapes, and student interview transcripts, an initial set of categories was used to trace each target students' participation in the learning community. These dimensions include: ownership of and commitment to writing tasks, using a variety of resources in writing projects, asking questions to clarify thinking, participating in a variety of activities to stimulate thinking, engaging in purposeful editing, engaging in writing as an ongoing process, and increasing control over multiple aspects of the writing process. These categories were later revised to include those described in Table 1 for the purposes of comparing the qualities of the learning community in writers' workshop with the science learning community. Transcripts of mini-lessons and writing conferences were also analyzed in relation to the teacher's role in supporting students' participation and learning in the learning community.

To learn about students' growth in writing knowledge, skills, and dispositions to write, their written work, audiotapes of writing conferences, and interviews were analyzed using the following categories: themes explored in writing, writing style and voice, forms of writing experimented with and used, use of language structures, correct use of mechanics, and awareness of and attention to audience. Students' development was traced chronologically, using the curriculum overview to locate events in real time, discover themes and patterns, investigate discrepant events, and seek confirming and disconfirming evidence (Erickson, 1986).

Developing frameworks for comparison. To compare and contrast writing in the two subject areas, we developed three additional frameworks. Throughout the year, the LISSS group participants discussed qualities of the learning community we were striving for within and across subject matter areas, but when we analyzed our data separately we tended to describe the qualities in subject-specific terms. The qualities in Table 1 represent qualities we hoped to foster across subject matter areas and provided a way for us to initially compare and contrast the intended and enacted curriculum in science and writer's workshop and to examine the purposes writing served and the nature of the interaction surrounding writing. The categories in Table 2 (to be discussed below) represent broad similarities we discovered in the science and writing curriculum and learning communities. These categories enabled us to examine more closely how we framed and carried out writing activities in each subject area:

1. The teacher develops curriculum strands that are interwoven over time, and include a focus on developing a learning community.
2. The teacher uses writing tasks as learning tools.
3. The teacher connects writing tasks to a wider range a learning activities.
4. The teacher scaffolds student thinking and participation in the learning community.
5. The teacher creates writing and other learning tasks that are congruent with norms of interaction in a learning community.

Finally, as we sought ways to organize our analysis to characterize the differences in writing in the two subject matter areas, we noted that our interactions with the students and the way the writing assignments were structured and carried out seemed to be the critical places to look. The categories in Table 3 (to be discussed

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below) represent contrasts in the teacher's role in supporting student learning in relation to the following areas: writing tasks and subject matter goals, purposes for writing, using writing to meet individual learning needs, choice in writing tasks, ownership, audience, and response. Our discussion below is organized around the similarities we found in the curriculum and learning community (Table 2) and the contrasts we found in teacher roles (Table 3).

Similarities in the Science and Writers' Workshop: Curriculum and Learning Community

While it was obvious that the subject matter content we taught in science and writing were quite different, we found some key similarities in our curriculum. These similarities functioned in significant ways in fostering the kind of learning setting we had in mind. Table 2 summarizes five broad similarities we uncovered and provides examples of how these ideas were enacted in science and writers' workshop.

The Science and Writers' Workshop: Curricular Similarities

The science curriculum across the fall and the writing curriculum across the year each consisted of three major strands that were emphasized differently but woven gradually together (see Table 2, #1). In both science and writers' workshop, two of the three strands focused on subject matter content. The third strand focused on learning what it means to be part of a scientific or writing community. These "learning community strands" included similar goals (see Table 1) which we each worked toward in different subject matter contexts.

In science, the year began with a focus on understanding the nature of science and scientific work, emphasizing the roles of evidence, discourse, writing, and collaboration. This study engaged students in considering their own roles in learning science and in constructing scientific knowledge in a community of learners. The science learning community strand continued to be a central piece of the units on adaptations and food for plants. The adaptations unit (the second curriculum strand) focused on a central problem: Are there more different kinds (species) of plants and animals in the desert or in Michigan?

Students studied plant and animal structures and their functions and observed a variety of plants to figure out ways they are adapted or not adapted for desert life. They consulted books and videotapes to learn about the diversity of life that is adapted to live in the desert while they simultaneously analyzed the work of scientists they encountered in the books and videotapes. They also reflected on ways in which our science classroom was like a scientific community. In the end, students did not have a definitive answer to the central problem, but they had begun to question their prediction that there are definitely more plant and animal species in Michigan. This failure to reach a definitive answer or even a class consensus was used to illustrate the nature of scientific inquiry and to consider diverse ways in which we (and other scientists) could continue to gather evidence to help us with our question.

The next unit explored how plants get their food (the third curriculum strand). Woven into lessons about photosynthesis were pieces of the other two strands. Students reflected on ways in which they were or were not acting like scientists in their efforts to answer the question: What is food for plants? The class also revisited desert plant adaptations for getting and conserving water: How does photosynthesis help us understand why plants need water, anyway? Ideas about structures and functions introduced in the adaptations unit were developed in more detail as students discovered and explored internal structures in plants and considered their functions. An underlying theme across the fall months was one of collaborative and joint inquiry, as the class pursued questions and problems together under Roth's leadership and guidance.

In writers' workshop, the fall months included three units designed to help students learn to collaborate as writers (the first curriculum strand), to use the writing process strategically (the second curriculum strand), and to examine their

Table 2

Similarities in Curriculum and Learning Community

Science	Writers' Workshop
1. Teacher develops curriculum strands that are interwoven over time, and include a focus on developing a learning community.	
* Nature of science and inquiry in a science learning community * Adaptations * Food for plants	* Creating and supporting the learning community * Developing writing knowledge and skills * Developing literary understanding and appreciation
2. Teacher uses writing tasks as learning tools.	
* reflect on data * make new connections * construct explanations * revise ideas	* develop and use author's craft * participate in range of experiences as authors * learn to participate in community of writers * revise text
3. Teacher connects writing tasks to a wider range of learning activities.	
* read * share * discuss * debate * inquire * collaborate * celebrate	* read * share * discuss * respond * inquire * collaborate * celebrate
4. Teacher scaffolds student thinking and participation in the learning community.	
* elicit students' current ideas and beliefs * challenge students to examine ideas * help students revise ideas * provide occasions for students to use ideas * celebrate learning	* students generate texts * encourage sharing and response to text * help students revise texts, using appropriate strategies and drawing on appropriate models * publish and celebrate
5. Teacher creates writing and other learning tasks that are congruent with norms of interaction in a learning community.	
* use writing to share and explore ideas publicly * encourage all learners to share ideas * encourage learners to show respect for diverse ideas * create opportunities for collaboration on joint problems and questions of mutual interest	* share and explore texts publicly * encourage all learners to share texts * encourage learners to respond to texts with respect and caring * create opportunities for collaboration on joint problems and questions of mutual interest

aesthetic response to literature (the third curriculum strand). They each wrote a piece called "All About Me" that served as a focal point for getting students to examine and experiment with how to draft, revise, edit, and publish a piece, as well as learning to collaborate in improving their drafts. In the second unit, they participated in a group project in which students created a group piece, an illustrated alphabet page. In addition to actually collaborating to produce their piece, they reflected on ways in which their collaboration was or was not successful across the unit. In October, they learned about and practiced different descriptive writing techniques, which led up to creating a written tour of their "haunted" school. In this unit students explored ways in which exaggeration and the five senses are used to create vivid description (curriculum strands 2 and 3). Again, they reflected on their collaboration to create the tour (curriculum strand 1).

In early November the format of the classroom changed from more teacher-led activities to a workshop format where students had more independent writing time and regular times to share their own writing and published literature. They explored ways to respond to each others' writing that would be constructive and helpful to the writer and experimented with different forms of writing (e.g., poetry, stories, narratives, more alphabet pages, pop-up books, essays) (curriculum strands 1 and 2). Mini-lessons focused on finding meaningful topics, experimenting with different writing forms, and response to writing. The year closed with units in which students continued to write their own pieces while the class explored two questions: (a) In published and our own writing, what is the relationship among the author's topic, purpose, chosen form, and audience response? and (b) Where do authors get their ideas, and how can published literature provide ideas and models for good writing? These units emphasized the third curriculum strand while still drawing on the first and second strands.

In both subject matter contexts, while students were learning conceptual understandings and skills, they were also learning ways of knowing and ways of being in a learning community--either a writing community or a science community. While the subject matter contexts varied, the qualities that were valued in our learning communities and the kind of learning culture that was developing were consistent. In science, students were learning to ask questions, generate hypotheses, and critically appraise evidence to support hypotheses, contributing to their emerging understanding of how knowledge is constructed in a scientific community. In writers' workshop, students were learning to articulate their aesthetic response to literature and critically appraise reasons why a particular piece evoked a particular response in them, contributing to their emerging knowledge of what constitutes "quality" in literature. In each context, each students' ideas were valued as important starting points in their learning.

In each context, writing played a central role as a learning tool (see Table 2, #2). In science, writing was used as a way for students to make their thinking visible and to examine and revise their thinking. Students wrote to get their ideas down, considered alternative explanations through reading and discussion, and revisited them to see if they had changed. These written texts became vehicles for generating discussion among peers about science concepts.

Written text was also a vehicle for generating discussion among peers in writers' workshop (see Table 2, #2). Discussions centered around three main types of interactions. Mini-lessons were taught regularly to introduce new content to students (e.g., descriptive writing techniques, topic choices, use of details in writing) and generate discussion about published literature as models and how to improve one's writing. Students shared their own writing and their favorite published literature regularly. Through this sharing, audience response was emphasized with an eye toward helping students make explicit their responses and identify aspects of the author's craft that may have evoked a particular response. A third type of discussion took place during writing conferences, sometimes held individually between teacher and student, and sometimes held at four-desk clusters where one students' writing was discussed by students and teachers. The focus of the conferences varied, depending on where the student was in the writing process (drafting, editing, publishing), and the student's writing needs (e.g., spelling and mechanics, use of detail, word choice, plot structure, voice in writing). Students were engaged in discussion about text as often as they were engaged in generating text so that participating in a community of writers came to mean more than getting a writing assignment done.

Writing in both contexts connected integrally to the wider range of learning activities (see Table 2, #3). In science, students wrote every day across the fall months (e.g., drawing pictures, writing descriptions, generating lists, writing in journals, writing a letter, keeping research charts, recording predictions and observations). Each day that they wrote, the writing was connected to the ongoing inquiry (about scientists, adaptations, food for plants) and served as a record of the students' thinking. Often, private writing became public as students used their written thoughts as evidence to support a point, and public writing (e.g., lists the class kept) was owned by everyone. As students constructed understandings over time with Roth's guidance and support, there were moments of spontaneous celebration when the group had achieved consensus. Additionally, some students chose to go beyond specific required writing tasks by conducting and writing about experiments they conducted during recess and at home.

In writers' workshop we tried to help students see meaningful connections between our discussions of student-generated texts and the published literature they shared with enthusiasm. Routines such as sharing time that were carefully planned for certain days of the week spilled over into other days, as though students could not get enough of hearing each others' writing and sharing their favorite literature. They also began to write outside of class, collaborate with each other over the phone, and share pieces with friends outside of our class and school. Moreover, some students began to make other connections by writing about social studies topics during writers' workshop. For example, Heidi composed a poem in which she expressed her feelings about slavery, a topic that her social studies class had recently studied. Timmy brought in an illustrated book about the Civil War to share during our literature sharing time. Lucas brought in some family documents that related to his great-grandfather's involvement in the Civil War. We aimed toward developing the understanding that reading and writing are an integral part of our lives both in and out of school, and saw signs that students had a similar understanding.

Science and Writers' Workshop: Learning Community Similarities

We each saw our responsibilities as supporting students in their thinking and in their participation in the learning community (Table 2, #4), and tried to frame writing experiences in ways that were congruent with the norms of interaction we hoped to generate in our learning community (Table 2, #5). In science, writing stimulated students to clarify and articulate their positions and ideas. Once these ideas were written down, they served as a still image to be preserved and examined at a later date. As students interacted with new ideas and experiences, they revisited their ideas and revised them. These preserved, written images representing their ideas helped students integrate new ideas with their prior knowledge and supported them in tracking and articulating more clearly their developing understandings. These still images were also an important source of information for Roth to understand students' thinking. She could use that knowledge instructionally both in her interactions with individuals and in whole-class discussions. These reflections on students' thinking took place in a culture of trust, caring, and respect, where all students were encouraged to participate and all contributions were considered respectfully. Since the inquiry was a joint effort among students, it required multiple contributions and multiple interpretations before consensus and understandings could be constructed.

In writers' workshop student texts were treated as personal endeavors with which members of the learning community, including the teachers, might be able to be helpful. A primary focus in talk about text was on understanding the author's intentions so assistance could center around helping the author realize his or her own intentions instead of around advice that dictates what the audience (often the teacher) thinks the person should write. Talk about writing strategies and techniques was intended to match the needs of the piece and the author's purpose, which required careful listening, caring, and respect for the author as a person.

Writers were also encouraged to share with other students with whom they felt comfortable, and we worked hard to help students see each other as a valuable audience. For some, this required a different way of thinking about whom they were writing for, since they were used to seeking only the teacher's approval for whatever they wrote. We encouraged them to at least begin by sharing with a partner, and then to move on to sharing with a small group or the whole class. The writer was in charge of this kind of decision.

Lesson Excerpts to Illustrate the Similarities

A Science Lesson

A lesson that took place early in the photosynthesis unit illustrates ways in which Roth made students' writing visible and open for public revision as well as connected to a group task of trying to figure out the best possible explanation about how plants get their food. The lesson began with each student writing privately about his/her ideas about two questions:

1. Write down your ideas about how plants get food.
2. Write down your ideas about what kind of food plants use.

As children constructed their responses, Roth circulated among them, reading their responses and providing individual encouragement to clarify and expand ideas. She then used this writing as the text for a classroom discussion to generate hypotheses about how plants get their food. Roth reminded students about the norms of listening and talking in this science learning community:

> What I would like each of you doing is listening to each other, to see what you think of other people's ideas. Are they similar to yours, or different? Do they have some good evidence for their ideas? Or do you have some different evidence for something else? OK? So today we're getting up our ideas about food for plants--our hypotheses.

The lesson then became a discussion about different student hypotheses, which were considered and then added to a class list of "Hypotheses About Food for Plants," a huge chart posted on a bulletin board in the front of the room. In future lessons, the students would examine and consider multiple sources of evidence to support or refute each of the hypotheses, but in this particular lesson, the goal was to consider multiple hypotheses, to show respect for each hypothesis, and to challenge hypotheses in the spirit of a scientific community.

Roth was teaching students about ways of being in this scientific community, and she modeled an acceptance and respect for all ideas while also challenging students' thinking in the spirit of a group inquiry around a shared question: How do plants get their food? The students' writing became central in the text of the discussion, and the discussion became a vehicle for engaging all students in the central question. Ideas from three students who were typically silent in academic discussions became central in this discussion. For example, Roth took advantage of a contribution by Keri, a girl who faced frequent teasing both for her Native-American heritage and for her learning difficulties. Keri had asserted that soil and dirt were two different hypotheses about how plants get their food. When Roth asked for clarification ("Somebody tell me about those two words. What are you thinking about when you say soil? Is that the same as dirt?"), Keri responded, "I think the dirt is um, more, um, dirty or something. Because they clean the soil." There were many giggles across the classroom, but Roth (KR) took the response seriously and affirmed Keri's (K) thinking:

KR: OK, I know what you're saying . . . that some soil, like if I went out in the playground right now and I dug up some dirt, is that soil or is that dirt?

K: That's dirt.

KR: That's dirt. Where would I find soil, Keri?

K: In the supermarket.

KR: In those bags, in the store? OK, for right now I'm going to leave these two words separate: dirt and soil. But some people think they're the same thing, and some people think maybe they're different. Right now, let's leave them separate, because we're just getting our ideas down now. We may change our minds later.

After this affirmation of Keri's "funny" idea, it is interesting that two of the academically strongest students in the class, Matthew (M) and Sarah (S), picked up on and expanded Keri's idea:

M: They talk about treated . . .

S: I think soil is the treated stuff. So I think fertilizer and soil are like more of the stuff that humans buy for the plants and the sun and the dirt is just natural food.

R: OK, when you say the soil is treated, what do you mean by that?

S: Well, like, if you go up and dig up the dirt, you don't find these little white foamy things in it, and if you buy soil from the store, it's, it, the soil looks more dark, and it's more moist and stuff. It's just, it looks more fresh than like if you out and dig up the . . .

Russell was a student with serious emotional problems due to a difficult home situation. He had spent a week at the beginning of the school year at an Outward Bound type of self-esteem building camp. In this discussion Roth encouraged him to share his writing with the class and then pushed the class to consider seriously his idea about air:

KR: Tell me what you're thinking about air, Russell.

Russell: Well, I was thinking, since um, it's an organism, that like animals, and we need air so I thought they might need air, too.

KR: Since animals need air that maybe plants need air? OK, would you consider, Russell, air a food for us?

Russell: Kind of.

KR: How many people would consider air to be a food? What's our definition of food?

??: Energy?

KR: Energy. Does air provided you with energy, to live and to grow?

Sarah: To live!

KR: To live, yes. That's a good point.

??: 'Cause if you didn't have air you would die.

KR: Does anybody know if air has energy in it that you can use? Sarah?

Sarah: Well, I don't know, I don't know that, but I just wanted to say that people that are like poor and dying and stuff 'cause they don't have food and stuff, well they have air. If air was food, why would they be dying?

Maria: That's a good argument (said quietly to Sarah)

Roth: OK, that 's a good argument. Right, Maria! That was very nice. Maria complimented Sarah on a good argument. That's a good, that is a good argument. People who are starving, they still have air, but they're still dying. Russell?

Russell: I just remembered the um, we use the air and the trees use the dirty stuff in the air . . .

KR: They use what?

Russell The like, the dirty stuff in the air.

KR: Something else in the air?

Russell: Like the pollution.

KR: OK, when you say they use it, do you think it could be food for them?

At this point Roth asked for a show of hands to see how the class was thinking about Russell's idea that air might be food for plants. She noticed that Nan, a student who struggles both academically and socially, was now convinced that air could not be food for plants. She called on Nan and then patiently interacted with her as a strategy for pulling her into the learning community and into the shared question, "How do plants get their food?" Although Nan's idea, like Keri's, could be perceived as funny or "odd" (which is how most students perceived Nan to be as a person), Roth took her idea seriously, both accepting it and challenging it:

KR: What convinced you, Nan?

Nan: What?

KR: What's your reason for thinking air is not food for people?

Nan: [pause] 'Cause you can't . . . [pause] . . . I don't know.

KR: You just think it's not food. What's a good reason for air not being food? What's a good scientific reason for air not being food? Go ahead, Nan.

Nan: 'Cause sometimes, it's, it's you know, if you're outside, you get air in your lungs, it's not food, because the air outside is bad for you, because it might, if the air is dirty, because of, of pollution.

[Note: She has clearly heard Russell's comment about pollution in the air and is using that idea in developing her own reasoning.]

KR: OK, so pollution is not food for you, right? It's not good for you. But what about, think about, Nan, think about our definition of food? What's a key word in that definition of food? What does food supply us with?

Nan: [very quietly] Energy?

KR: Energy. Okay, air, if we gulp air, we can try to chew it, pretend it's food, but it doesn't give us energy. And I think Sarah's argument was a pretty good one. You could imagine, you could sit in this room all day . . .

??: With air.

KR: With air. By the end of the day, if that's all you ate, you'd be starting to feel pretty weak, because you would be running out of energy.

[Lots of student laughter as both Roth and students pretend to chew the air]

KR: So air does not supply us with energy. Do you think it might supply plants with energy? What do you think? Keri?

Keri: I think it does because it cleans our air, so I think the stuff that we breathe out is good for them [plants] but not for us.

KR: OK, so there's different things. I think what Keri's getting at and Russell is getting at is that there are different things in the air, and what they're saying is that maybe some of those things are energy for plants, or food for plants.

Roth ended this portion of the discussion by highlighting ideas from Keri and Russell, students who would typically be invisible or made fun of in academic settings. She summarized the discussion by putting these students' ideas in writing on the class hypotheses chart; their ideas that started privately with their personal writing became public and were seriously considered throughout the unit.

This lesson excerpt illustrates each of the features of "similarities" included on Table 2. First, the lesson illustrates how pieces of three curriculum strands are woven together. Roth not only engaged students in considering how plants get their food; she also explicitly talked to students and modeled behaviors of a scientific community of inquiry. Ideas from the adaptations strand also appeared, such as when Russell used the idea that both plants and animals are organisms to support his hypothesis that air is food for plants. The concept of "organism" had been introduced in the adaptations strand, along with ideas about structures of organisms and their functions. Second, the lesson shows how writing--both personal, individual writing and public writing on the hypothesis chart--was used as a tool in constructing an explanation about how plants get their food. This lesson was the beginning of a long process which involved students in continually reconsidering the evidence to support or refute each of the ideas proposed as possible sources of food for plants.

Third, the writing done by the students was closely linked to the class debate and the collaborative inquiry into the issue of how plants get their food. The writing students did at the beginning of the lesson was designed to stimulate a rich discussion of multiple hypotheses; it was not just a writing assignment to be turned in for a grade or to be checked off as "completed." The writing was integral to the development of ideas and to the activities and experiments that were to come in the days to follow. This writing was revisited on multiple occasions. Fourth, writing was used to elicit students' current ideas and beliefs and to provide a classroom text that enabled the teacher to challenge students to reconsider and revise their thinking. Both as they were writing and as they were sharing their writing publicly, the students were supported by the teacher and classmates in clarifying their ideas and in providing evidence to support their ideas.

Lastly, the teacher created a writing task that was structured in ways that fostered important norms of interaction in a scientific learning community. For example, the initial writing task was designed to help students feel safe to share on paper their "real" thinking (rather than trying to figure out what the teacher wanted); the emphasis was on writing about your ideas. Private feedback from the teacher during the writing time provided encouragement that perhaps enabled some students to feel more willing to share their ideas publicly. During the public sharing of ideas, teacher scaffolding danced the fine line between encouraging and respecting all kinds of responses while also challenging students to reason and defend their positions.

A Writers' Workshop Lesson

After three introductory units in which students learned about a variety of writing techniques and strategies, Rosaen and Lindquist changed their teaching format from teacher-led activities where all students worked on assigned writing tasks to a workshop format. After a brief mini-lesson, students had independent writing time to choose their own topic, form, and pace for each piece. They also had regular times to share their own writing and published literature.

A typical writers' workshop segment on November 20 illustrates how the three curriculum strands were interwoven and how writing activities were connected to the development of the learning community. The class period began with a brief mini-lesson in which Lindquist reviewed with students the variety of techniques the class had examined in published literature and experimented with in their own writing since September. She began by asking for examples of different kinds of revisions. Jake volunteered that he added details to his piece to clarify some of his ideas. Nan deleted some information that she thought did not fit with her piece, and Heidi deleted some repetitious material. Matt re-read his piece to make sure it made sense and added information as needed. The class continued, reviewing the different techniques they had practiced in the previous three units: using exaggeration, using alliteration, making verb tense consistent, writing interesting lead sentences, adding details about personal reactions, and improving word choice. Lindquist was making a deliberate attempt to get students to make connections between the techniques and strategies students had learned about previously and their potential use with the students' current pieces.

She then said, "Let's try to make some connections about revision," and asked the students to think back to their photosynthesis unit in science. She reminded students that they had written down their beginning definitions of food for plants, and then revisited and revised their ideas later on in the unit. Then she commented:

> That's revision. In science you had some thoughts about what your ideas were about food for plants. You worked with those and you did experiments, you learned some things, and over the process of a few weeks, you have changed some of your thoughts about what food for plants is. That's the same thing as revising in writing. You start out with your draft and you get your thoughts down--that's the important thing, to get your thoughts down--and then you work with them. You experiment by trying these different techniques and looking at those to see if you can improve on your paper using any of those. You experiment by sharing your piece with somebody else, seeing does it make sense to them, do they understand it, do they get the message that you were trying to get across. It's the same process of changing. Revision is changing or seeing--remember we talked about revision, it's re-seeing? Okay, so you're changing your thoughts, you're thinking things through a little bit more.

Lindquist was trying to help students see that their peers played an important role in revising (building connections between curriculum strands 1 and 2, Table 2, #1) and that there were parallels between the way ideas are examined and revised in science and the way texts are examined and revised in writers' workshop (Table 2, #2). She concluded the mini-lesson by asking students to pay attention to where they were in the writing process that day and to be aware of whether they were going back and forth among drafting, revising, and editing. She wanted students to perceive the recursive nature of the writing process and not reduce it to a linear set of steps to follow.

The mini-lesson was followed by individual writing time. Rosaen's conferences with students at a four-desk cluster illustrate ways in which she tried to scaffold students' thinking and participation in the learning community (Table 2, #4) and focused on helping these emerging writers realize their own intentions as writers. Her talk about writing strategies and techniques was intended to match the needs of the piece and the author's purpose. For example, when Heidi asked Rosaen to read a piece she had drafted about spending time at her grandparents' house, Rosaen began by asking Heidi to give her some direction in what to look for in the piece:

Rosaen: Okay, Heidi, can you tell me a little bit about what you'd like me to look at it for? What kinds of things are you wondering about?

Heidi: Anything that's listed up there (points to list of techniques on blackboard).

Rosaen: Okay, now that's an awfully big list so it's going to be hard for me to think about all of those things at one time. From this list that's on the board, what do you think you'd like to concentrate on in your revisions?

Heidi: I guess I could add some senses.

Rosaen: You want to think about that?

Heidi: Yes.

Rosaen: Okay, now why don't you read this out loud to me.

As Heidi read her draft, she noticed that one part did not make sense and stopped to add some points of clarification. Then she continued reading until the end. Rosaen responded initially by commenting that she noticed Heidi's use of the senses in her description to affirm that Heidi already used the technique. To help Heidi continue to grow as a writer, Rosaen decided to point out another technique that might improve the piece and used her own response as a rationale for why using the technique might be helpful:

Rosaen: Now actually, I noticed that you did add some senses in here as you were working your way though.

Heidi: Yeah, like right here.

Rosaen: You know, one thing that I was thinking about is, I know you've said that you really have fun there, but if you added more details about your reactions to things, you would convince me more that you were really having fun. I know you believe that. But let's imagine that I'm reading your thing and I'm saying, "I'll bet she's just saying she has fun at her grandma and grandpa's house. I'll bet she doesn't really mean it." Are there reactions that you could add in here that could really convince me? Let's think about that.

As the conference proceeded, Rosaen showed Heidi concrete examples of places where she could add details about her reaction to events, eliciting specific reactions from Heidi for each spot they considered. When she noticed that Heidi was struggling with ways to express her reactions, she acknowledged that this kind of revision was not easy and tried to support her in her struggle:

Rosaen This is hard. Let's think about it. What's fun about hiking and exploring in the woods? Imagine you're out there right now. There you are, out there, looking for sticks and hiking. What's fun about it?

Heidi: Me and my brother like looking for wild animals. We like looking for deer.

Rosaen: Okay, so once you get out there you start looking for other things and you start exploring? Okay, and do you try new places? Do you always know where you are?

As they finished up their example, Rosaen concluded the conference by reminding Heidi that the choice of adding details was still up to her:

Rosaen: So you could, if you wanted to, add some more details in this spot about what goes on out here that could help me believe that this statement [about having fun] is true.

Heidi: I've got more to think about for this part for reactions, plus I could add a sentence and say, like, um, "Once in a while, me or my brother step on a snake and it scares us."

Rosaen: Terrific! So that's two ideas. Now, the other thing we have to think about is how to manage making these additions because you don't have enough space right here to add all that. Did you like that cut-and-paste method that I showed Nan? Did you see me do that with her, where we actually cut her paper in half and made room for her to add more details?

When Rosaen noticed that Heidi had written on both sides of the page and the method Nan had used would not work, she showed Heidi a different method for adding revisions. Heidi was ready to begin her work on revising, and had some specific ideas in mind to get her started.

In the same manner, Rosaen proceeded to participate in writing conferences with Sarah, Michelle, and Nan. In response to where each person was in the writing process (drafting, revising, editing, publishing), Rosaen tailored the conversation to meet the needs of the author (for further learning) and the piece (to help the author realize her intentions). Rosaen began each conference by finding out where the student was in the writing process and what kind of piece she was working on. To begin her conversation with Sarah about her draft of a story about going up north, Rosaen probed, "Tell me a little bit more about what you want to talk about in your piece." After listening to a long explanation of Sarah's ideas for her plot, she helped Sarah think about ways to begin the book that would help the reader feel as though she was experiencing packing for the trip with the narrator.

Nan identified the kind of assistance she needed to proceed with her piece by explaining, "I just got done editing. Could you read it and make sure that I got all the words spelled right? I already checked through it, but I want to make sure I did them all right." To bring Nan into the editing process, Rosaen responded, "Okay, what I'd like you to do is read to me one sentence at a time and let's look at each sentence." This enabled Nan to get more practice at identifying misspelled words and discussing correct spellings; it also provided a way for Rosaen to point out other mechanical problems and work on them with Nan.

Michelle began her conference by reading her entire narrative aloud. Rosaen responded by trying to find out more about what Michelle was thinking:

> Rosaen: Okay, do you have questions that you want to talk about with this piece? Are there things you're wondering about that might help you improve it?

Michelle: I was wondering if the part about Bandit chasing fish sounded okay. (Inaudible)

Rosaen: You're asking me was it clear?

Michelle: Yeah.

Rosaen: Yeah, it did [sound clear]. You know what I was thinking here, thinking about this list that's on the board of things that you could think about improving it with. I think this piece could use some five senses.

Michelle: I already have some.

Rosaen: You have some in here already, like you said, "She's soft and cuddly." Now, "pretty." I can't see her. I can't see what color she is. I can't see what size she is. I don't know if she's big or fluffy, or what kind of a cat. So you could help me see her better.

Michelle: That's pretty good. Okay.

At this point in their conference, Michelle seemed to understand the general task--to add more detail--and she understood that using the five senses was one way to develop details. However, to make sure she had some concrete images of the kinds of things she could add, Rosaen probed more about the cat's physical characteristics to get Michelle talking about her. Rosaen's purpose was to help Michelle realize what an expert she is on her subject, and how many details she had at her disposal to include.

Rosaen: That would be one thing. I like this part a lot where you wrote about the running around and stuff. Are there sounds that might go with this one?

Michelle: Yeah, stomping and barking!

Rosaen: There you go, you have all kinds of ideas.

Michelle: For like, pretty, I could put like what color she is, and say how skinny of a cat she is.

Rosaen: Yeah. Let's see, you said she's part Siamese and part tiger. So that part I think I can picture. I know what the body type is of a Siamese.

Michelle: Yeah, but she sort of looks more like a, she's got Siamese part in her face, she looks like a Siamese in her face. But then her markings are really tigery.

Rosaen: See now that would really be interesting to hear more about what she looks like. Also, does she sound like a Siamese cat with that low cry? They go, Grrrrrr. Does she sound like that?

Michelle: (laughs) Yeah.

Rosaen: See that could be interesting. I think you know a lot more about this kitty than you're telling me yet. You just got started. This is great so far.

As she did with Heidi, Rosaen asked Michelle if she needed to learn about a strategy for adding the details and proceeded to show her some options.

Each conference illustrates the personal nature of the scaffolding Rosaen provided for her students in relation to their learning needs and the importance of sharing in improving one's writing (Table 2). She was candid about her response to their drafts, being careful to be encouraging and supportive but yet helping each student learn more about how to use her knowledge of writing techniques and strategies to improve the quality of her piece. As the year proceeded, Rosaen and Lindquist helped students become less focused on the teacher as respondent by providing regular opportunities for students to share with each other. Eventually, students spent more time helping each other improve their drafts and placed less emphasis on seeking the teacher's response.

Lesson Similarities

These examples illustrate how strong the connections were between the curriculum and the learning community in both science and writers' workshop (see Table 2). Students were engaged in meaningful discussion and exchange of ideas while being supported in learning how to do so. Writing was not only an end in and of itself, but a tool for learning that had integral connections with other classroom activities. In each context, the teacher played an important role in supporting students' thinking and participation in the learning community and created tasks that are congruent with the norms of interaction in a classroom focused on learning. The lessons illustrate how the social context in which teaching of science and writing takes place is a powerful representation of what it means to be a writer or a scientist. As Maria's and Sarah's conversation excerpts at the beginning of this report illustrated, it is also a powerful context for helping students understand the multiple purposes writing can serve. Yet we are still reminded that the writing students did in the two contexts contrasted in many ways. In the next section we discuss contrasts in our roles in supporting student learning to try to understand better what made the writing in each context unique and we examine the significance of the contrasts.

Contrasts in the Teacher's Role in Supporting Student Learning

On any given day, a visitor in our classroom observing both science and writers' workshop might see more obvious differences than similarities in the nature of the writing students were engaged in and in the purposes the writing served. As we analyzed our curriculum, our learning community, and our roles in supporting student learning, it was our roles in structuring and carrying out writing activities that stood out as the primary source of these contrasts. Table 3 summarizes seven areas of contrast that we will discuss in detail. Rosaen begins by discussing her role as teacher in writers' workshop, using a case description of how she supported two students, Maria and Sarah, in learning to write. Roth then discusses her role as teacher in science and how that connects to her use of writing to support students' science learning. She illustrates her discussion with examples of her interactions with students during the photosynthesis unit. We conclude by highlighting the contrasts and discussing implications for teachers in planning writing experiences.

Rosaen's Role in Supporting Learning in Writers' Workshop

When Lindquist and I began our collaboration, we saw ourselves as learning professionals.[3] We were both experienced and knowledgeable language arts teachers who were inexperienced at using a writers' workshop instructional model. We each drew on our unique backgrounds and experiences to support each other as we made a transition from using more traditional approaches to teaching writing to working within a writers' workshop format. As the year progressed, we became more skilled at listening to our students to understand better their needs and interests as developing writers. Our changes enabled the curriculum to become more responsive to and specifically focused on our students' particular learning needs and interests. As we found ways to provide occasions for students to engage in the range of decisions authors make and sought ways to support their development as writers along the way, we saw in our students an increased commitment to and interest in their writing and fuller participation in our learning community (for more detailed discussions of students' development as writer in the context of the learning community, see Rosaen with Hazelwood, in press; Rosaen & Lindquist, 1992; Rosaen, Lindquist, Peasley & Hazelwood, 1992).

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[3] See Rosaen, C. L., & Lindquist, B. (1992). Collaborative teaching and research: Asking "What does it mean?" (Elementary Subjects Center Series No. 73). East Lansing: Michigan State University,

I analyzed the roles we took on in trying to support our students' learning in relation to the seven areas listed on Table 3. To illustrate how these roles played out for individual writers, I explore examples of my interactions with the two students, Maria and Sarah, whose comments about writing were previewed in the introductory section of this paper. These interactions took place between mid-February and the end of May during the last two units of the school year, Authors' Design and Authors' Exploration.

I became interested in exploring my interactions with Maria and Sarah for several reasons. Sarah is a white female from a middle-class family. She is a typical "good student" who readily completed assignments and yet seemed to begin the year writing more for her teachers than for herself. She frequently sought feedback and

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Institute for Research on Teaching, Center for the Learning and Teaching of Elementary Subjects, for a more detailed discussion of our collaboration and learning.

assurance from me about her writing, and did not seem particularly interested in hearing from her peers. In fact, I sometimes wondered why she shared her writing with me because she seemed to be more interested in talking about what she saw in her own writing than in hearing my feedback. She participated daily in class and kept her hand raised throughout discussions. During both whole-class and small-group interactions, Sarah tended to dominate. It was not hard to notice Sarah's participation on a daily basis, and she sought interactions about her writing regularly.

Maria is a Mexican-American student who was quiet in class. Early in the year I noted that she was unsure of her writing abilities. When I interacted with her about her writing at the beginning of the year, I noticed myself saying things that I hoped affirmed her strengths as a person as well as trying to support her in her writing. Maria rarely participated in class discussions and frequently looked like she was not paying attention at all. Sometimes when she raised her hand she would put it down again, as if she either changed her mind about participating or forgot what she was going to say. Yet, as I studied her participation more closely, I learned that she did a great deal of writing across the year and did participate in our learning community in her own quiet way.

Maria and Sarah formed a writing partnership early in the year that may have been sparked by participating in a four-person group with whom they completed an assigned project. Together, they began a chapter book about teen life and they eventually drew other students (including boys) into contributing chapters. In addition, their book inspired several other students to write their own chapter books about teen life. For a time, the various teen life stories dominated our Wednesday sharing sessions as well as our students' writing in and out of school. I became interested in learning more about how two girls who were so different in their confidence levels, cultural backgrounds, academic success, apparent social

Table 3

Contrasts in the Teacher's Role in Supporting Student Learning

Science: A Conceptual Change Instructional Model	**Writing: A Writers' Workshop Instructional Model**
A. Writing tasks and subject matter goals	
Teacher determines writing topic, purpose, audience, form, in relation to teacher-planned inquiry process and science concepts goals.	Teacher determines writing content and process to be taught in relation to student selection of writing topics, purposes, audience and form.
B. Purposes for writing	
Teacher defines expressive and transactional purposes for writing.	Teacher encourages expressive, transactional and poetic purposes for writing. Teacher emphasizes relationship among three purposes and ways different purposes can help students improve their writing.
C. Using writing to meet individual learning needs	
Teacher responds differently across students to same writing tasks according to individuals' science learning needs.	Teacher responds to individually defined writing tasks according to individuals' writing learning needs.
D. Choice in writing tasks	
Teacher chooses to structure writing topic, form, & purpose while balancing assigned writing tasks with allowing choices in writing topics and forms. Enables opportunities to have students examine publicly similar sets of ideas over time.	Teacher encourages student choice of topic, purpose, audience and form. Enables students to experience full range of decisions authors make and provides opportunities for teacher to support students as needed in writing process.
E. Ownership	
Teacher encourages ownership of ideas more than ownership of writing.	Teacher encourages ownership of text, which includes ownership of ideas in text.
F. Audience	
Teacher is primary audience for student writing. Students write *to* teacher, not *for* teacher.	Teacher is member of larger audience which includes peers. Students write for self and/or audience.
G. Response	
Teacher responds orally and in writing to ideas in text. Peers respond orally to ideas in text.	Teacher and peers respond orally to multiple aspects of text (e.g., topic, form, writing techniques, ideas in text, overall reaction).

status in the class, and participation in the larger learning community worked together and what my role in supporting their learning might be. How did I define subject matter goals and attempt to meet their individual learning needs? How did choice, ownership, audience, and response influence their writing experiences and what role did I play in facilitating those experiences?

Subject Matter Goals and Purposes for Writing

When we launched the workshop format in early November, we provided a series of mini-lessons on poetry writing as a stimulus for getting students to stretch their imaginations regarding writing topics and forms. By February our classroom was flooded with writing of all kinds and abundant interactions surrounding these texts. Although we had supported students in learning to respond to each other's pieces, we were concerned that our patterns such as having students share their own writing and their favorite literature should not become mere routines without substance. We wanted these recurring experiences to help them grow as writers. For example, my February 6 journal entry indicates my perceived need to go beyond general sharing and celebration to supporting students in learning to give more focused feedback:

> Today is author's day. Timmy is ready to share generally. We could be doing more with getting kids to share for a particular purpose. I think we're ready to go beyond general sharing to use sharing to get help, assistance, feedback--more for helping with techniques. It's also important to celebrate writing, but I think integrating sharing for particular purposes would help keep sharing fresh, focused, purposeful.

Our Authors' Design unit was created in response to this need. In this unit we focused on how authors plan and design pieces. We framed our study around two broad questions: (a) How do authors make decisions about their topic, main idea, audience, desired audience response, and written form to plan, design, and create a piece? and (b) How does the authors' design influence and shape the writing process (prewriting, drafting, revising, editing, publishing)? Since students were in charge of making decisions regarding their topics, writing purposes, audience, and form (see Table 3, Section A), we took responsibility for helping students develop strategic awareness and skills in planning and designing their pieces. We also saw this as a way to discuss the quality of pieces: Does my piece evoke the type of reaction in my audience that I had in mind? Why or why not? Moreover, the authors' design framework made the relationship between purposes for writing (expressive, transactional, poetic) and the form of writing more prominent: What form of writing best suits my purposes (see Table 3, Section B)?

One way we modeled and supported thinking about these issues was to discuss published literature. In social studies class where other LISSS colleagues were teaching, our students were learning to read their textbooks critically by using concepts such as the following to think about historical events and their portrayal in written texts: perspective, democracy, freedom, liberty, equality, justice, rights/duties, racism, prejudice, discrimination, sexism, exploitation, power and empathy.[4] They had discussed the role of women, children, and enslaved people in history, and were just beginning to study Native Americans. To build on their learning in social studies and connect it to our study of literature, we discussed with our students poetry written about and by Native Americans to consider the extent to which the poetry evoked empathy for Native Americans. After reading a set of poems we asked students, in groups, to select one that they felt best helped them understand and empathize with the Native Americans' experiences, and why. We tried to support students in finding specific examples that would help them understand and make explicit why and how a particular poem had evoked an empathic response in them.

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[4] For a detailed description of the social studies curriculum and students' learning, see Hasbach, C., Roth, K., Hoekwater, E. & Rosaen, C. with LISSS Colleagues (in press). Powerful social studies: Concepts that count (Elementary Subjects Center Series No. 88). East Lansing: Michigan State University, Institute for Research on Teaching, Center for the Learning and Teaching of Elementary Subjects.

Following this, we read a poem entitled "Girls Can, Too!"[5] by Lee Bennett Hopkins and asked our students to consider what the author's message meant to them personally and ways in which the design of the piece may have contributed to their response. After both Sarah and Heidi read the poem aloud, Lindquist asked, "Okay, what about empathy with this poem? How does empathy fit into this poem, do you think?" As usual, Sarah's hand shot up immediately and she responded, "He's trying to get you to feel how the girl felt." As the class explored what that meant, one idea that emerged was, perhaps the girl in the poem was better than the boy and that the author wanted us to realize that girls are better than boys. This was followed by a lively discussion and much disagreement about whether that statement is accurate or not. Finally, Nan wanted to take a poll: "Who thinks girls are better than boys?" As hands were raised, Lindquist raised follow-up questions such as, "How many people aren't sure? [How many think] that neither are better? That they're equal?"

Throughout the questioning, fervent hand-waving, and lots of side conversations, Maria raised her hand to both "aren't sure" and "equal." She made a side comment to someone sitting next to her, but did not offer a comment to the group. In contrast, Sarah ventured, "Okay, we might be a tad bit?" In the face of much opposition from several students, she offered the qualification, "I think girls are better than boys in some ways and boys are better than girls in some ways . . . Girls can have babies and boys can't." When others persisted in wondering if that means girls are better generally, Sarah replied, "Yeah, but I just think girls can do stuff that boys sometimes can't."

To this line of thinking Lindquist raised the question, "Do you know what this conversation reminds me of? Of thinking back to at the beginning of the year when we talked about stereotypes in science? . . . Do you think we might be stereotyping?"

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[5] This poem is printed in a volume edited by Lee Bennett Hopkins entitled Girls can, too! A book of poems, published by Watts, New York, 1972.

Sarah replied firmly, "Having a baby is not a stereotype." While debate continued along these lines for several minutes, Maria looked anxious and a bit puzzled as she kept raising her hand and putting it down again. She looked as though she was trying to retrieve an idea she kept forgetting. Maria's hand finally stayed raised and when Lindquist called on her, she said, "I forgot." It seems that both Sarah and Maria were engaged in thinking about the issues raised in the poem, but only Sarah participated in the debate publicly.[6] Class discussions like this encouraged me to dig more deeply to understand how Maria and Sarah were experiencing the support in thinking about writing that we were trying to provide.

Supporting the Composing Process

We used the authors' design framework to get students thinking about their own writing in a similar way. This entailed trying to get students to see that the teacher is but one member of a larger audience, their peers, and helping students learn to respond to others' writing in helpful ways (see Table 3, Sections F and G). For example, on February 27, Sarah chose to share the beginning of a piece entitled "Isn't Teen Life Wonderful?" This was a piece she collaborated with Maria and others in the class to write (each author was responsible for writing a different chapter, but they collaborated on ideas). The student who had shared before her had been asked to explain who her audience was for her piece and what reaction she had hoped to evoke. In turn, Sarah began by explaining who her audience was and what reaction she hoped to evoke in her readers. Instead of modeling a response to the student texts, I chose to highlight ways to move the sharing process along in my comments and leave the response to the piece to the larger audience, her peers. When the students did not specifically respond to whether their reactions matched Sarah's intentions, I intervened to raise the question. These aspects of my participation are underlined in the excerpt below:

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[6] Sarah and Maria showed similar differences in participation in social studies. Through close study of their participation, very interesting differences in their learning were also uncovered. See the report cited in footnote 4 for details on contrasts in the girls' learning in social studies.

Sarah: I'm writing this for myself, and for Maria, and Ed.

Rosaen: Those are the only three people you think would ever read the story?

Sarah: Well, no, and I was writing it for anybody who wanted to read it, but . . .

Rosaen: Do you think grown-ups would be interested in reading it? Did you have a certain age group in mind?

Sarah: Teenagers, and like, from ages 10 through about 17, 18-years-old. Well, I want you, when I read this I want you to feel like you're actually going along with me, like, um, it won't say like, I went to (inaudible) class and then to (inaudible) class. I'm gonna describe it like, um, like you're, I want you to feel like you're there too.

??: Okay.

Lindquist: Speak louder, Sarah, it's really hard to hear you.

Sarah: My piece is called "Isn't Teenage Life Wonderful?"

"Happy birthday," my friend Maria exclaimed as I dragged my tired body through the junior high door. March 16th, a new year, 15 years old, supposedly a new life. Yeah, right. Just then Ed walked by, so cute, so fine, and also number 52 on the basketball team. His good looks immediately woke me up. Just then the bell rang and I rushed to my first class, social studies. I can't wait.

I took a seat between Maria and Alex. Maria was doodling on her notebook, "I love Ed, I love Ed." Maria is so lucky, she gets Ed and I don't. Just then Maria passed a note. It said, "Dear Sarah, Alex looks good today but Ed looks better. Love, Maria. P.S. Write back."

Maria always wants me to write back. I didn't know what to say. I just wrote, "Dear Maria, I feel the same way. Sarah."

That's all I've got so far.

Lindquist: So you're going to add to the rest of it?

Sarah: Yeah, it's gonna be long so I'm reading it in pieces. Each author, they all have a different section.

Lindquist: Okay, I think you've got some comments here.

Nan: Who in real life is Ed?

Sarah: He's a boy that rides my bus and goes to Moore and he's really really cute. Heidi?

Heidi: I like the way that you really explained how you were feeling when you got up (inaudible).

Sarah: Thanks. Alex?

Alex: Why did you choose to write something about teenagers?

Sara Because, because it's an interesting subject, and um, and basically what I'm writing is what I wish would happen. I'm not finished with it yet.

Rosaen: How about the reaction that Sarah was hoping that you'd have that you would kind of feel like you were there with her seeing what she saw. Do you think that she was successful at that?

??: I think I could [see what she saw].

Sarah: Later I'm gonna describe Ed better and like bring new characters in my story.

Throughout the unit we worked back and forth between modeling and discussing response to published texts using the authors' design framework and encouraging students to use the framework to respond to each others' pieces during sharing time.

During writing conferences we tried to help individual students become more aware of their own writing process, such as reflecting on where their ideas come from and how they develop them along the way (see Table 3, Sections C and D). After Maria and Sarah had been working on their teen life story for quite some time, I focused my conference with them on two areas. First, I wanted to learn more about how they had composed the piece; I needed to know what their intentions were if I was going to support them in writing the piece. Second, I wanted to help them become more aware of their own composing process so they could reflect back on it to understand what is helpful to them when they write and what is not.

Maria and Sarah tended to summarize their text instead of describing how they were writing it. Underlined sentences in the excerpts below show how I probed to find out more details about the composing process:

Sarah: I want to read chapter 3 . . .

Rosaen: Now you seem, you're going right to that chapter. Can you tell me why that's one that you especially want to read right now?

Sarah: I don't know, it's our new one and we think we're getting, it's the last one we wrote and we think we're getting better each time, but . . .

Rosaen: Better how?

Sarah: Like, the first chapter, I mean think we're getting better as we write because we know more of our subject and we're getting more into it.

Rosaen: So what's making the writing better?

Maria: Well it's our . . .

Sarah: I think we're getting into it and it's coming to exciting parts 'cause we're not just . . .

Maria: It's more interesting.

Sarah: We're not just telling, see, in the first two chapters we really had to tell where we are, what our life is and stuff like that.

Rosaen: OK.

Sarah: And so now we're, now we're kind of getting into it.

Rosaen: So now you're kind of digging into the actual story?

Sarah: Everybody knows, everybody knows what happens and everything like that.

Rosaen: OK.

Sarah: So this is in the second part. OK, we were just at lunch and we're jumping, OK (begins to read), *Soon biology was over. It was time to go. Yay! Kay and I and Maria . . .*

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(after Sarah reads draft)

Rosaen: Maria, tell me how you're, you're writing this together. Now I see that Sarah's actually writing it down?

Maria: Well, I did half of it . . .

Sarah: She wrote this part.

Rosaen: OK, you do some of it too?

Sarah: Yeah, but we both like . . .

Maria: . . . write ideas . . .

Sarah: She'll go home and think, "Oh, this would be a neat chapter," and write it and then I come and I say, "Oh yeah, this is good, " and then I add my thoughts into it.

Rosaen: OK.

Sarah: So we're kind of collaborating.

Rosaen: So you're really doing it together then.

Maria: Uh huh.

Sarah: Yeah, but sometimes I just end up doing the writing.

Rosaen: And where are your ideas coming from?

Maria: Well some of this is true . . .

Sarah: And some of it isn't . . .

Maria: It's really happening, like, in our first chapter . . .

Sarah: Yeah, like Maria, we wrote it the day that Maria did pass a note to me and say, "Aaron looks good but Ed looks better."

Rosaen: OK, so that's something, you started . . .

Maria: Some of it's really happening . . .

Rosaen: . . . with some real things.

Sarah: Yeah, and then and then this is just kind of like a fantasy, you know . . .

When I noticed that Sarah was tending to dominate the conference, I tried to pull Maria into the conversation by asking her a direct question about her role in the writing process. I knew that she was playing a key part in writing the chapter book and wanted to make sure both she and Sarah were aware of Maria's contributions (see Table 3, Section E). Yet whole-class experiences were not a fruitful place for me to find out about Maria as a writer or to support her as a writer.

From this conference, I was able to learn about the actual collaborative process, for example, that the girls worked on their piece outside of school and that they worked interactively to generate story ideas. I was also able to ascertain that Maria felt ownership for the chapter book, that despite Sarah's more dominant presence in sharing the piece with others, Maria agreed that she shared authorship with Sarah. Since Maria's participation in our learning community was so private and unobtrusive, a conference like this was an important source of information about her level and style of collaboration. It was important to know that she had a prominent role in composing the piece even if she was not prominent in sharing it with others.

A Source for Struggle

Early in the year we worked hard to shift students' perceptions from thinking that writing is done by students for the teacher to believing that authors realize their own intentions through writing and that teachers and peers are available to support that process. Gradually, we saw students take on increased control, voice, rights, and responsibilities as writers. We had not anticipated fully what might happen when students shared control over the curriculum more democratically (Shannon, 1989) and found the need to further redefine our roles as teachers in ways that would reflect shared control (see Table 1, teacher's role). Maria and Sarah taught us a great deal about this issue.

One problem we bumped up against was that students were more enthusiastic about generating texts for their own social purposes than they were about improving the quality of their writing (our academic purposes). Maria's and Sarah's teen life story seemed to have more to do with building connections in their social lives at school than with learning to write better. Recall that in response to Alex's question about why she chose to write about teenagers, Sarah responded, "Because, because it's an interesting subject, and um, and basically what I'm writing is what I wish would happen." In the following excerpts from a small-group sharing session, the underlined portions show how I struggled to keep the focus in the conversation on helping Sarah and Maria learn about students' response so they could improve the quality of their writing (academic purposes), while the students continued to pursue what the next plot events would be (social purposes):

(Sarah has just finished reading her draft)

Rosaen: Did you want some reaction or did you just want to read it?

Carey: I like it. I liked it a lot!

Sarah: I don't know, did anybody . . .

Jake: I liked . . .

Rosaen: What did you like about it?

Carey: Everything.

Rosaen: Everything.

Jake: I already knew that she liked Barry. She told me.

Carey: Everybody knows she likes Barry.

(overlapping comments)

Ed: What chapter, what chapter are you going to put in that you kiss him?

Sarah: Well listen to this chapter, I mean my gosh this is a sleepover. We rented the whole darn Holiday Inn. Do you think we would sleep alone?

(group laughter)

Sarah: I mean (laughs) . . .

(group laughter)

Carey: She says, "Do you think we're gonna sleep alone?" (group laughter)

Jake: Have fun.

Sarah: I didn't mean it that way!

Rosaen: Is there a way that when people read you could be a more helpful audience than to just raise your hand and say "Can I read?" as soon as they're done? Remember when I said, did you come over here to just read or did you come over to be an audience?

Carey: To be an audience.

Rosaen: What about some of the others of you? Can you offer a comment that could help Sarah know how she's doing?

Mona: I could. I thought it was pretty neat that she said that (inaudible) . . .

Sarah Can I go over there with Maria and Mrs. H. because they're interviewing . . .

Each time I review this segment of conversation I feel anew the struggle I experienced at the time! I also recall my intense feelings of frustration when Mona offered a comment to Sarah about how she responded to a particular part of the story and Sarah ignored it by saying she wanted to leave the group and talk with someone else about her story. For me, experiences like this raised fundamental questions about my role and responsibilities as a writing teacher: When students share control over writing decisions, what are appropriate ways for teachers to provide ongoing instruction that still honors their control? When differences in teachers' and students' perceptions arise, how should these differences be resolved?

My response to these issues the next day when Jake read his chapter (a continuation of Sarah's and Maria's story) show that I had not come very far in figuring out what to do next. Once again, my comments were aimed at getting students to respond to aspects that I thought were important (e.g., getting the audience to state explicitly their reactions) while students' actual responses showed that they were still caught up in the plot development as it related to their social lives:

(Jake is reading the end of chapter 5 after Sarah shares chapters 2 and 3)

Jake: . . . *gave me a kiss and the bell rang. So I went home and pinched myself to make sure I wasn't dreaming. But sure enough, I had red lipstick on my cheek.*

(overlapping comments)

Rosaen: Is there anything you want to ask your audience?

Maria: I've got to say something. Sarah and Jake, um, on chapter 5, it skipped over to his party.

Sarah: I know 'cause I'm not finished with chapter 3 yet. 'Cause he wrote this at home.

Maria: Oh.

Rosaen: Do you want to know anything about their reaction?

Carey: Sarah was about to cry. She had water in her eyes.

Sarah: No, I just . . .

Rosaen: Do you want to know anything? Do you want to ask them anything?

(overlapping comments)

Laticia: I want to say something.

Maria: Just say it.

Rosaen: Laticia, go ahead.

Laticia: (inaudible) This is true life (inaudible).

Carey: What?

Maria: They do go together.

Laticia: For real

Sarah: OK, OK, it's partly true, partly true.

Jake: What's partly true?

Sarah: The story.

Jake: Partly. Not chapter 5 though.

Sarah: Maria's going with Ed and . . .

Ed: Are you going with Johnny?

Maria: She doesn't like Johnny, she likes Jake.

Buddy: Let's get to reading!

Rosaen: Jake and Sarah, was there anything that you want to ask your audience? Was there a reason that you read this, that you wanted to find anything out?

Sarah: Ohhhh . . .

Ed: Is it romantic?

Jake: Yeah, how romantic is it?

Carey: A lot.

Sarah: Yeah. Did you like it?

Carey: You should have seen Ed. He was over there laughing so hard.

Ed: I like the part where the milk man came . . .

What I can see now that I could not see at the time is that the students did not need to talk *about* their response because they were *living* their response by showing their interest and delight in the story development. Jake and Sarah probably had no trouble seeing that the audience was greatly entertained by their chapters. The audience also seemed to share the authors' purposes--to live out some teenage fantasies vicariously, perhaps to behave more boldly in their social lives on paper than they might in real life. For example, Laticia was assertive about pointing out that she knew which events were true or not, which may have been a way for her to carve a niche in the actual social situation.

At first I thought of these experiences as examples of the students' *resistance* to my curricular intentions and the support I tried to provide. I felt troubled that they were not embracing the response process in the way I had envisioned, and worried that these struggles would somehow dampen their enthusiasm for writing. However, Lather's (1991) discussion of research approaches that empower those involved to change as well as to understand the world helped me think about them differently. She discusses the point that in understanding relationships of power, using the idea of "reasons for resistance" implies that we (teachers) are right and those resisting (students) are somehow wrong. In contrast, the idea "sources for struggle" (Lather, 1991, p. 134) acknowledges the power of both teachers and students. If I saw students as "resisting" the "legitimate" reasons to share--to make one's response explicit by talking about it--I would miss understanding how they actually experienced the sharing sessions or what was legitimate for them. Alternatively, if I viewed these experiences as "sources of struggle" for both students and myself, I could better capture both sets of intentions and interpretations.

I came to understand, by listening to these students and thinking hard about why they behaved as they did, that genuine response can entail showing and not just talking (see Table 3, Sections F and G). If I recognized showing as a legitimate form of response I could build on that to also help students learn to articulate and explain their actions so they could learn to be more helpful to each other. I also realized that it was becoming increasingly difficult to find ways to deepen students' understanding of the writing process and their participation in our learning community that would complement and not work against my overall intentions of helping students become authors.

Joining Our Students in Learning

Our Authors' Exploration unit was an attempt to address some of the issues that surfaced out of our struggles. We maintained our commitment to support our students in improving the quality of their writing but worked harder to honor their current interests and need for autonomy. We thought of our task as developing productive ways to channel our students' intense interest and motivation in more fruitful directions. In this unit we explored two questions: (a) Where do authors get their ideas for writing topics and forms? and (b) How can different types of literature (e.g., mystery, fantasy, subject matter trade books, author study, and biography) provide ideas and models for good writing?

Instead of trying to second-guess what kinds of books students were interested in, we engaged them in some activities that would help us find out. For example, we explored the school library's book collection and asked our students to create a "wish list" for the librarian to use as a reference when she ordered new books for the coming year. We organized book exploration groups (based on their library work) to help students find others in the class who shared their interests in particular authors and genres. We framed open-ended questions to support the exploration process and joined our students in pursuing the questions: How or where do authors get their ideas for writing? What do authors do to make their writing better? How does using a specific form of writing make reading about a topic more interesting or enjoyable? What can we learn about improving our own writing by exploring a book set?

We suggested that students try a topic or genre that was either new to them or that at least might steer them in a different direction than they were currently going. Since it was getting near the end of the school year we cast this as a "capstone" experience for which they might carefully weigh what their final piece of the year might be. Some students embraced the opportunity and ventured into new kinds of writing or tried out new topics. Rusty tried (although he eventually decided to abandon) writing a series of poems about hamsters. Iris did some research on flowers before writing a poem about them. Tim tried writing an essay on sharks. Brenda tried writing her first mystery story (one of her favorite kinds of books to read). Maria and Sarah set aside their teen life chapter book and each began writing their own fantasy.

This unit was not without its own struggles. Even though we structured the book explorations so that students could pursue their own topics and interests, some students felt that the time spent on this focus interrupted their writing. For example, during an end-of-year group interview (5/23/91), Sarah made a point of telling me she did not like or benefit from the fantasy exploration group in which she and Maria participated:

> It wasn't really all that fun because we didn't get any special ideas. Because we would read the book and then we would read like the end of chapters and stuff like that. And really we didn't see much fantasy in them. We didn't get any ideas. . . . I already had an idea of what I wanted to write, but I couldn't write it because we were looking at books.

This source of struggle was not over what the students should talk about as in the previous examples, but over how students should spend their time. Sarah offered an alternative suggestion that could resolve the conflict:

> I think that if you had like a certain table that had books at it for fantasy, and then like if you were stuck for a topic you could say, "OK, I want to write a mystery," and then go to the mystery table.

Feedback like this from students has helped me think about alternative ways to provide support to students (see Table 3, Sections C and D) without taking away their control over how they spend their time to address their current writing problems or patterns (see Table 3, Section E). As Sarah said, they could have spent time exploring books as needed, rather than as the teachers legislated.

Thus, supporting students' writing development while making room for and honoring their own voices and rights was a difficult tension to manage. It required giving up many aspects of control that teachers have claimed for many years, while at the same time not abandoning our responsibility to provide instruction and support. As Calkins (1986) says, ideally writing classrooms will have both high student and high teacher input and "[teachers] need not be afraid to teach, but we do need to think carefully about the kinds of teacher input which will be helpful to our students" (p. 165).

Learning About Support From Maria and Sarah

I cannot understand whether my input was helpful to Maria and Sarah without bringing their interpretations and voices into the process. What did the experiences across this school year mean to them, and what part might this redefined teacher role (Table 3) have played in their learning? In relation to their starting points as writers at the beginning of the year, what are important areas of development? Sarah and Maria were interviewed formally at the end of the year (5/29/91 and 5/22/91 respectively), and a few times informally across the year. Their reflections about their participation and learning helped me pursue these issues.

Becoming part of the learning community. Both Maria and Sarah are aware of changes in how they participated as writers in our learning community. On November 8, Maria commented:

Maria: I thought I would never be good in English because last year it was just my worst class, so I'm like, "Oh no, this year I hope we don't have English because I'm going to be worse at it." Because I never thought I could do it because every year since third grade I've had a bad, you know, like score in English. I think I'm doing better this year.

Interviewer: Why do you think you're getting better?

Maria: Well, because, I don't know. It's just that, I just try to do more effort into it than just like listening and doodling and not even doing my work right . . . But this year I think it's a lot more funner.

Interviewer: Do you think you've put in more effort this year?

Maria: A lot more effort.

Interviewer: Like what? Give me an example of effort.

Maria: Well, like when we had to work in our group, like last year, I never liked to work in the groups. I'd just sit there and just doodle and not even pay attention and this year I'm more into the group than I was last year. . . . In my group I can work with them more than I could last year.

What we as teachers perceived to be somewhat a lack of participation was, for Maria, an increase compared to previous years. Even though she did not participate actively in our large-group discussions, her actual participation in group work was an important step for her.

Maria also gained confidence in herself as a writer, which seemed to support her in participating in our learning community, at least in small groups or with Sarah. This confidence seemed to develop by learning more about what the writing process entailed, and learning that authors are people who write. She commented during her end-of-year interview:

Maria: Well, in writing workshop, see before I didn't like writing because I never knew and then we started talking more about authors and things, going through steps. I sorta like got interested in it and I, you know, I thought, well, if we can talk about authors I can put myself into authors', you know, feet, and just act like an author.

Interviewer: Okay.

Maria: When we go through the steps, like how to make your piece better, by putting details, you know, authors.

Interviewer: So, you feel more like an author now?

Maria: Yeah.

Interviewer: You feel like it's not just this big foggy idea now, there's like certain things that . . .

Maria: Yeah. You could just sit there and you could think, "Oh, I know what I could write!", write it down, then go back through it and make your corrections, erase things that you don't want. . . . Before I couldn't do that. I had to sit there for about like five, ten minutes before I'd think of a piece.

Interviewer: Okay, and you realize that there are steps now that you go through?

Maria: Yeah.

Interviewer: Like you come up with an idea and you go back to it and revise it and you can go ask yourself questions to help you go further?

Maria: Because we get papers like that and we have to go, "Well, what do you think makes authors better at writing?" And you sit there and you *think* for a while and when you think more in like, now, you know, you get the feeling like oh, gosh, "I'm an author!" 'Cause you write things down that you're doing.

Maria's more limited learning community, mostly her world with Sarah, was where she learned to share and improve her writing:

Interviewer: When do you share your writing?

Maria: I don't really share in front of the class. I usually share, you know, two people, you know, me and Dr. Rosaen, Ms. Hazelwood, I just share with those guys the pieces. I really, the one I really did it with was Ms. Hazelwood, where we sat down a lot and we've shared our ideas. So I'm pretty close to her on my pieces, like my personal pieces. I talk to her about them.

Interviewer: Okay.

Maria: And when no other teachers are available.

Interviewer: So you don't do a lot of sharing with classmates?

Maria: No, I [share] individually with people.

Interviewer: Okay, do you share with Sarah?

Maria: Yeah, that's really actually the only person I share with . . . she respects my feelings and she won't laugh at my pieces if they're wrong. She'll just help me correct it. . . . I talk to her about them. I read them to her and I'll go, "Well, what do you think?" after. I'll get like her advice. I'll go, "What do you think of my piece? Should I change a little?" and she'll like say, "Yeah, Maria, you should change one part in there, two parts, or change it around," and do things like that.

Interviewer: Okay.

Maria: I ask her ways.

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Interviewer: Can you think of any other times that you could have shared something, a piece this year but you didn't?

Maria: I've, um, I could have shared a lot, like poetry, 'cause usually we have literature and poetry day on Wednesdays and Mondays, but I just would listen to people. I wouldn't get up there and share. So I could've shared all this year but I just didn't.

Interviewer: And why didn't you?

Maria: I'm just like scared people will laugh at me, you know, and make fun of my piece.

Maria's growing confidence was fragile and she was not yet ready to risk sharing with the whole group. In Maria's eyes, she was safe with Sarah and with her teachers and Hazelwood, (who talked with Maria a great deal about her personal feelings), but not with the entire class.

Sarah's end-of-year individual interview revealed a different kind of change in learning to become part of a learning community. She began the year participating often in whole-class discussions, but virtually ignored her peers as a potential audience for her writing and instead opted to seek out her teachers. She also began the year taking a dominant role in collaborative work. Her description at the end of the year of how she drafts a piece shows a different kind of connection to and interaction with her peers. She saw her peers as her audience (not her teachers) and she sought their help and advice:

Interviewer: So when you're putting all your thought into [a piece], what kinds of things are you thinking about?

Sarah: Oh, will my audience like it, is this easy to understand, how can I word it better so they aren't thinking something else when I want them to think about this? Let's see, when I read this sentence, what could you think about instead of what I want you to think about? And then like maybe Maria thinks other stuff so we have all these problems and so like we write them down kind of and then we say, "Okay, we've got to get a perfect piece here," obviously.

Interviewer: So you think some things are important and Maria thinks some different things are important maybe? Is that what you're saying?

Sarah: Uh huh.

Interviewer: So then you have to think about which ones . . .

Sarah: Well, then we have to hit all of them because I guess some people, I mean Maria is thinking these things so obviously some people might have a problem with these things.

Interviewer: Right. So you've learned some different things to think about?

Sarah: Yeah. So we write and we try to move, "Okay, is this hard to understand?" Okay, you know? It's like we write a sentence and then we go down the list. "Is it hard to under. . . okay, is it easy to understand? Yes. Check. Is the words great, are you thinking the right thing?" So we go over to like Sasha or something and say, "Will you read this and tell me if you understand what we mean here?"

Interviewer: Great.

Sarah: You know and we'll ask other people and stuff to get their input.

Along with seeking help from others on the clarity of her writing, Sarah came to appreciate the role sharing could play in judging the quality of her writing:

Sarah: We have this sharing corner where everybody goes back in the corner and you can share a piece if you want to.

Interviewer: Oh, great. So you do that with a lot of your pieces? So you can get extra help? You like that?

Sarah: Uh huh.

Interviewer: Okay, I'd like to ask why you share your writing. Are there any other reasons that you might share your writing besides getting help?

Sarah: Just for ideas. To see if they like it.

Interviewer: Okay, what about after your piece is finished?

Sarah: I share it because I want to know what their reaction is.

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Interviewer: So what do you think makes a piece of writing really good? Like how, when you're writing something, how do you know that it's really good?

Sarah: I don't know. I don't know. I don't know if it's good until I share it. When I share it and if everybody tells the truth and says it's good, if Brian tells me it's good then it's good.

Interviewer: What kind of criteria do you think people use to say that writing is good. What would you use to say that writing is good?

Sarah: Well, if I read it and I read it smoothly, like I just kind of read it and I didn't have to stop and look at the (inaudible) and say, what do they mean, and just, smoothly read the piece and then, "It sounds neat to me," then it's good.

Interviewer: What do you mean by neat?

Sarah: Like it just is interesting, a neat topic, interesting.

Both Sarah and Maria changed as participants in our learning community across the year. Maria's concept of herself as a writer helped her venture further (although not fully) into the community and explore ways this participation could help her as a writer. Sarah changed her definition of writing from that of writing for the teacher to believing she could realize her own intentions with the help and support of her peers. By collaborating and sharing she came to appreciate the value of her peers in helping her improve her writing.

Learning from struggles. Maria's and Sarah's reflections on writing their teen life story taught me a great deal about the importance of having the patience to wait for writers to draw their own conclusions about what they are attempting to do. Recall that during the Authors' Design unit I felt that students were ignoring the framework we were using to get them thinking about audience response (our academic goals) and instead focusing on how the latest plot of someone's teen life story would unfold (their social goals). Instead of interfering with the absolute flood of teen life stories that seemed to never end, we began the Authors' Exploration unit as a way to try to influence students to shift gears and try something new. Maria and

Sarah joined the fantasy book exploration group, and Sarah explained the sequence of events this way as she talked about the new fantasy piece she started:

Interviewer:	What did you pick first, your topic of bears or the idea that you wanted it to be a fantasy?
Sarah:	Oh, the idea that we wanted it to be fantasy, because we were supposed to pick a group and we were doing our authors' exploration unit to be a group subject, biography, or fiction. And we picked fiction and then we had to pick, even more than that, we had to pick what kind of group we wanted to be in fiction. So what kind of fiction we wanted, realistic, whatever, and the we decided that we wanted to do fantasy. That was what we wanted to do. And when we picked that group, we decided that we were going to write a fantasy.
Interviewer:	Okay, and then you started brainstorming topics and you started with the dolls idea?
Sarah:	Yeah, and then, and then Maria said, "Well, I like teddy bears, I don't really like dolls. You can make teddy bears really cute."

Unlike their teen life story where they divided up which chapters they would write, this time they diverged into writing separate pieces, although they both wrote about teddy bears. Maria commented, "See, 'cause the teen one was me and Sarah's and now this is mine, but she just helps me sometimes." Their partnership shifted from co-authorship to co-helpers.

As our end-of-year interviews with them continued, it was very interesting to learn how they perceived writing their teen life story in retrospect. Maria commented that she became bored with writing the teen story after a while, although she thought she learned something important from the process about the limitations of the teen life topic:

Interviewer:	Do you like this one [fantasy] better than the other ones or is it the very best one you've written?
Maria:	Well the teen one was like the best, but now that I've thought about, this one will probably be the best because I got bored with romance. A lot of romance you get bored with it, but adventures you can keep on adding more adventure. You can't keep adding more romance. Just keep on, you know, I don't, I get bored with it . . .

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Interviewer: Which piece did you learn the most about writing from?

Maria: Um, well, the teenage romance.

Interviewer: Okay, what kinds of things did you learn from writing that piece?

Maria: Well, like romance is, I learned that 'cause I like adventures, you know? I learned that you can't, when you're dong romance, you can't imagine, you know know, make things adventure.

Interviewer: Okay, and why did you think that you learned a lot about writing from this piece?

Maria: Well, I learn it because (pause), how can I put it? (pause) I learned a lot of it working with it 'cause romance wasn't, I learned it because romance wasn't my thing. I learned from it, you know, I wouldn't really write another romance again.

Now that she had a point of comparison, Maria could see her teen life piece differently. She could see that plot ideas were not restricted to what might be plausible and, perhaps, what would fit the real-life characters she and Sarah had included in their piece. She realized that this topic did not sustain her interest over time.

Sarah changed her mind about writing teen life stories for slightly different reasons. As she shared her chapters with different classmates, some of them were not as enthusiastic as others had been:

Interviewer: How do you think that this piece [fantasy] compares with other pieces that you've written this year? Do you think it's the best piece?

Sarah: Best, because when I was writing "Teen Life," I was writing it, I don't know, it kind of dragged. I went, that story, I've done since the beginning of the term, I've been writing that teen life story, that and other books in our series, and it kind of got dragged, I mean . . .

Interviewer: Do you think it's because you spent so much time on it, or . . .

Sarah: Well, I don't know, because like Sasha was reading it and it didn't have any suspense like I like to do now. And she just kind of acted like she was falling asleep, and I said, "Okay, this isn't good." You know, and it kind of dragged . . .

As with Maria, having a point of comparison helped Sarah to see some limitations in the teen life story that she could not see at the time. Sasha was not engaged in reading the story and Sarah began to suspect the reason was the lack of suspense, something she was working hard to include in her fantasy.

These interview excerpts are very interesting to me, especially in relation to the frustration I felt while Maria and Sarah were engaged in writing their teen life story. I was convinced that I was absolutely unsuccessful in getting Maria and Sarah to consider issues of quality as they were writing. I was convinced they had not heard a word I said. And I think I'm probably right. I think it was not until later, until our Authors' Exploration unit, that they were able to use ideas about quality (from our current and previous units) to appraise their teen life story retrospectively.

Consider Sarah's reflections about making the quality of her writing better:

Interviewer:	What do you think that you've learned this year about making the quality of your writing better?
Sarah:	Well, before "Teen Life" I was just like writing and writing and writing and I didn't bother revising or drafting or anything like that. I would just write and write and write. And then with the Authors' Exploration unit I started to kind of, make the writing a little better. Because like she said, "Okay, you can't just write a draft. 'Cause that isn't going to sell or isn't going to do anything that you want to do with it. You've got to make it better. Don't, don't write your whole book then revise the whole thing at once. Write a chapter, revise that chapter, draft the chapter, edit the chapter, publish the chapter, then write the next chapter." And see, but instead of doing that I kind of just, draft and edit and rewrite by myself while I'm just kind of doing it.
Interviewer:	So, but you feel different now, since then?
Sarah:	Uh huh, 'cause I used to just write and, "Oh well, it doesn't matter what it, it's never going to get published."
Interviewer:	So how do you think that's changed the quality of your writing, to do it this way?
Sarah:	Because now my writing is better because it's been edited and drafted and it makes more sense because I've gotten other people to read it . . .

When Sarah was asked about advice she would give to a teacher about what fifth graders should learn about writing, she again pointed to the Authors' Exploration unit as one that helped her become a better writer:

Sarah: Authors' Exploration unit, where you give them the books and the stations and tell them to make their writing better. Don't wait 'til the end of the year for them to start making their writing better. You need to do it right away.

Interviewer: Because you think that's what really was the turning point to help you write better?

Sarah: Uh huh . . .

Interestingly, this is the same unit about which Sarah had commented that she did not get any "special ideas" when she explored the fantasy book set. In her perception, this was our first attempt at getting students to work on improving the quality of their writing when, in fact, we had been focusing on making our writing better all year! Sarah's language indicates that something happened during this unit that made her feel more responsible for producing a high quality product, and we are not sure what that might have been. Perhaps it was framing this as her final capstone piece of the year, perhaps our approach in the unit was more meaningful to her, perhaps she was developmentally at a point in her writing where she was ready to attend to quality, or perhaps Sasha's boredom with the teen life piece really struck a powerful chord.

Maria also seemed to gain some specific ideas about writing quality from participating in the fantasy exploration group and also showed glimmers of readiness to venture into the larger learning community:

Interviewer: Now, thinking about writers and authors that you've read, which one writes in a way you especially like? Which one of those kinds of people?

Maria: Roald Dahl.

Interviewer: What makes you like his writing?

Maria: He does a lot of imag . . . his imagination, he uses good imagination, and adventure.

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Interviewer: What do you think would make your writing even better?

Maria: If I get more, if I get more . . . feedback. You know, just like, the positive feedback from people. Not, "Oh, I like it," Not like that 'cause you know there's something wrong with it. I would like to get positive feedback from people.

Interviewer: And what if they had negative feedback for you?

Maria: I would ask them what parts they didn't really like and they would tell me and I would go back and read it a couple times and then I'll make the corrections. . . if I do this piece by the end of the year, I want everybody to read it and I want them to give me feedback.

Both Sarah and Maria paid attention to different aspects of the writing community and different aspects of improving the quality of their writing at different times. The gradual but steady support was not evenly received and used across time. Instead, Maria and Sarah seemed to make sense of it and make it their own at a pace that matched their readiness.

The Writers' Workshop Instructional Model

This detailed example illustrates the struggles and dilemmas raised for teachers using a writers' workshop as an instructional model to support students in learning to write. Since Lindquist and I were still learning to share control over writing purposes, topic, form, and pace with our students and to develop new strategies and skills in supporting emerging writers' development, perhaps these issues stood out more prominently to us. Shaping writing tasks and subject matter goals in response to learners' interests and needs creates tensions and dilemmas for teachers in carrying out their responsibility to see to it that all students grow as writers. It is not enough to provide time, choice, and audience for writing. Teachers must figure out ways to foster growth but do so in ways that allow students to develop a sense of ownership for their writing and commitment to their own growth. Roth's illustrations of her interactions with students during the photosynthesis unit highlights different struggles and issues that arise out of using a conceptual change instructional model where writing is used as an important tool in supporting students' learning.

Roth's Role in Supporting Learning in a Science Learning Community

When I started teaching the fifth graders in Lindquist's classroom, I wanted to investigate the role that writing could play in students' learning of science. I knew that Rosaen and Lindquist would be investigating some new ways of teaching students about writing, and I was sure that our collaborative work in the Literacy in Science and Social Studies Project would stimulate and challenge my thinking about the role of writing in science learning. And I was not disappointed! Across the year I experienced several ups and downs as I compared and contrasted my use of writing in science with the way students were engaged in writing in writers' workshop. The ups centered around a growing realization among the collaborators that we were indeed establishing and reinforcing some consistent and productive norms of interaction in the science learning community and in writers' workshop (see Tables 1 and 2). The downs usually centered around the issues of choice, ownership, and audience in the writing tasks (see Table 3). I recognized that the students had much greater freedom and responsibility in making choices in writers' workshop than in science. It was exciting to see children making choices about writing topics and to see teachers moving away from the front of the classroom, coaching individual students and small groups of students in crafting their writing. I struggled to reconcile the authority I was asserting in determining the topics of study and the structure of writing tasks I assigned in science with the freedom of choice I saw embedded in the writers' workshop format.

Analysis of my roles in supporting student writing in science and of Rosaen's roles in supporting student writing in writers' workshop helps clarify and begin to resolve at least some of these dilemmas regarding the contrasts in our approaches to student choice, ownership, and audience in writing. Analysis of students' learning in the two subject areas contributes additional insights which support the position that a writers' workshop instructional approach may not be most appropriate for students' learning in science. The comparison of teacher roles and student learning and growth also helped me identify ways in which a conceptual change instructional framework may be particularly appropriate for science instruction but not as useful in teaching students to become writers.

In particular, my goals of helping students to develop scientific explanations and scientific ways of thinking and to understand natural phenomena in increasingly powerful and yet personally meaningful ways differed in important ways from the writing teachers' goals of helping learners make choices about writing decisions in expressing their own knowledge and experience. In a scientific community, there is a continual effort to use shared methods and norms of inquiry to reach a consensus about the best possible explanation and about the remaining questions to be explored about this explanation. Thus, both knowledge and process are shared by a community of scientists. In contrast, a community of writers shares ideas about effective writing strategies but values diversity in terms of the substance and content of the writing as well as each individual's response to the writing. In creating stories, poems, autobiographies, and plays, writers draw from and describe the uniqueness and individuality of their experience while striving to create images that will allow readers to link that uniqueness to their own unique experiences. The consensus that writers share centers around standards of quality in writing rather than in the particular ideas that are the subject of a writer's creation. Thus, writers strive to develop shared understandings of "quality" (an inherently subjective term), while celebrating diversity and individuality in both the content of the writing and the responses to the writing.

In writers' workshop, for example, each student's unique aesthetic response to text is heard and valued; the teachers push the students to explicate (although not necessarily reach full consensus) about those aspects of text that evoked a particular response. This is not quite the same as the goal of trying to come to shared understanding of the knowledge and concepts embedded in the texts we create in science--developing shared understandings about how to explain the world around us. For writers, the shared community knowledge focuses on the writing process and the author's craft, while in science the shared community knowledge focuses on how particular scientific processes lead us to shared understandings and creation of concepts that explain our experience in the world.

Understanding writing and science as human activities that are distinct from each other (as well as similar) suggests that the teacher's role in science and the teacher's role in writing instruction might need to be distinctly different. This distinction suggests that it might make sense that students should often be pursuing individual topics in a writing workshop while working together on a shared problem in science.

Below I illustrate the roles that I played in supporting students' writing and learning in science through a description of lesson interactions across a 2-week period of time in November-December during the photosynthesis unit. These lesson examples will be used to highlight the ways that my roles as science teacher differed from Rosaen's roles in writers' workshop (see Table 3). A discussion of students' learning about photosynthesis and about the nature of science will follow the lesson descriptions.

Designing and Assigning Writing Tasks in Science: Subject Matter Goals and Purposes for Writing

What roles did I play in creating writing tasks in science and in supporting students' writing in science? One way in which my role was significantly different from Rosaen's was that I chose a common topic, or set of concepts, that would serve as the centerpiece of our work together in this science learning community. I chose "food for plants" as the topic for our late fall curriculum for several reasons. First, my research experience with teaching this topic to other students gave me confidence that I could use it to help all students grow significantly both in their understanding about the nature of scientific inquiry and in their understanding of important central concepts in science (food, energy, photosynthesis, structure, function, etc.). A key part of my instructional goal was to help each student make significant conceptual change--for each student to experience what it takes to reason scientifically, to use evidence and collaborative work to change their understanding of the world around them. Because of this overriding goal for students' science learning, I chose to have our classroom operate as a scientific community, with each person contributing to our developing understanding of a shared problem: How do plants get their food? Because the problem was a shared one and one chosen by the teacher, the writing tasks in science generally focused on engaging students in this shared problem and in supporting students' developing thinking about this problem.

As described in the science classroom excerpt above (pp. 25-31), the unit started by having students write down their ideas about this central problem. Students' ideas were shared publicly in a classroom hypothesis chart that grew into an unusual data chart. Instead of the usual charts of numbers or graphs, this data chart consisted of students' writing about evidence that supports or refutes a given hypothesis. The list of initial hypotheses about sources of food for plants included:

fertilizer
sun
dirt
soil
minerals
other plants; dead plants
stuff in dead birds
water
makes its own
air, pollution in the air
bugs, flies
nectar

stuff carried by bugs (pollen)
liquids (root beer, juice)
powdery stuff you buy at the store
something in grass clippings
hair
care

We will see how this evidence chart grew--becoming covered with "yellow stickies" on which students wrote down emerging evidence to support or refute each hypothesis--as we look at excerpts from the unit that highlight the teacher's role in creating, responding to, and shaping students' writing in science.

After these initial discussions about hypotheses, the students completed an experiment (planned by the teacher) with bean seeds in which they investigated whether the bean seed embryo could grow when it was detached from its cotyledon. When the bean embryo failed to grow unless attached to its cotyledon, some students made the intended connection that the cotyledon contains food for the growing embryo. Many of these students also decided that while the growing embryo uses food from the cotyledon, the grown plant must use some other kind of food (water was a popular hypothesis) because the cotyledon is eventually used up. However, many students did not make the connection that the cotyledon was supplying food to the growing embryo. Instead, they asserted that the water was the food for the embryo but that the embryo couldn't absorb the water unless it was attached to the cotyledon--that the cotyledon was some kind of special drinking system for the embryo.

Picking up on students' thinking about this issue, I started the lesson on November 14 by asking students to write in their journals about their current ideas. Although I wanted students to put down their thoughts honestly, I needed a better understanding of particular aspects of their thinking in order to plan fruitful activities. Therefore, I structured the questions carefully to stimulate writing that would help me assess where students were in their thinking about water as a source of food for plants and that might lead to a discussion that would challenge students to reconsider their ideas:

> We're starting to get some good evidence to figure out our question, "What is food for plants?" And yesterday, an idea came up, several people seemed to be thinking that maybe the food for the little embryo--what I call the baby plant--maybe the food for the baby plant is different from the food for the grown-up plant. So what I'd like to start with today is in your journals, on the next page, put today's date . . . three questions I want you to--you don't need to, make sure you don't copy the questions, don't copy the questions, just answer them. The first one--and what I want you to put down is your best thinking at this moment. You may change your mind later but what is your best thinking today about "Is water food for growing embryos?" What do you think? So you can put down, "I think water is not, because. . . . And then "What's some good evidence?" Think back to our experiment with the bean seeds or maybe to our experiment with the grass plants. See what evidence you can give. [Student questions] The second question is "Is water food for the grown-up plant? What's your evidence?" [Some students ask questions and talk about an experiment that Billy did at home] So for number 3, what I want you to write down is, "What are some questions that you have about food for plants right now?" What are some things that you're puzzling about or wondering about?
>
> Written on the board:
> 1. Is water food for the growing embryo? What is your evidence?
> 2. Is water food for the grown-up plant? What is your evidence?
> 3. What are some questions that you have about food for plants right now?

In assigning this task, I strove to convey several important messages about ways of being in this science learning community and about what is important in their writing. The questions were structured to scaffold students' thinking about a particular idea--the role of water for the growing embryo and the grown plant. By raising the questions in the context of some students' assertion that the baby embryo's food might be different than the adult plant, the writing task challenges students to reexamine their assumptions. The questions ask for evidence, encouraging students to use evidence and directing students to particular experiments that they might think through as they construct their written response. The third question communicates to students that they should have questions and confusions, and that such questions can make a good contribution to the group's deliberations about the problem of plants and food.

Teacher Role During the Writing

As the students wrote their responses to these questions, I wandered the room reading each student's entry and supporting them individually in constructing better responses. To me a "better response" meant that it accurately captured their complete thinking and that it pushed their thinking about the ideas about food and plants and bean seeds. I did not care at all about spelling, grammar, or writing style. In fact I wanted to minimize their choices as writers ("You don't need to copy the questions"), so they could focus as much as possible on the ideas. As I coached students individually my overriding concerns were: "Do I understand what this student is really thinking? Can I find out more about this student's thinking? Can I ask a question that might challenge the student to see a new piece or a new angle?" I noted that many students were raising their hands and asking me to read their ideas, a positive sign that they felt comfortable with my role as a coach in the writing process. The following examples of individual mini-conferences with students illustrate my attempts to coach each student individually, helping each student respond in productive and personally meaningful ways to the same assigned task.

> Nan's journal entry:
> 1. I think water is not becous it has not grow and it is git water.
> 2. I do think it is food becous they grow so the water is food for the plant.
> 3. I wond like to know why water is not food for us. I wond like to now why water is not food for plants if it grows with just water then it is food for plants.

KR: Okay. Remember I said sometimes we have a problem with this word "it"?

Nan: Yeah.

KR: "I think water is not because it has not grown." What do you mean by "it"?

Nan: The plant.

KR: The embryo or the whole plant?

Nan: The embryo.

KR: OK, that would help me understand what you're saying better. What you can do is sort of just stick it in like that. OK, that's excellent thinking you're doing . . . "Because they have grown." Now when you way "they" you mean the plant?

Nan: Yeah.

KR: The big plant?

Nan: Yeah.

KR: Those are super questions, and we will be able to answer those pretty soon. Super!

Nan is a student who is frequently pulled out of science class for speech therapy and reading support. I chose to focus in this conference on helping her to use words more clearly to communicate her ideas. I wanted her to feel both safe and successful in sharing her ideas with the class in our group discussion, and I knew that she needed to be more precise to be successful. I applauded her questions, noting to myself that they reflected a genuine quandry for Nan--she seemed to recognize that there was good evidence to support both sides of the question about whether or not water is food for plants. I was pleased that she was not just accepting my proclamation that water is not food for us, but instead pushing to make sense of that: "I wond like to now _why_ water is not food for us. "

> _Michelle's journal entry_:
> 1. I don't think water is food for the embryo alone beacuse in the bean experament water didn't help the embryo grow.
> 2. I think water [unfinished]

KR: That's excellent. You gave really good evidence. The second one--once the bean plant runs out of food in the cotyledon? Do you think then it uses water for food? Or what do you think it starts using for food after that?

Michelle: I think it needs water and then maybe, sometimes some people do, put plant food. And . . . remember those little white things?

KR: Oh, like the fertilizer?

Nan: Fertilizer?

KR: Yeah, OK . . . [Interrupted by Tiffany at the same table]

Michelle had not completed her journal entry, so I applauded the careful use of evidence in her response to the first question and then tried to support her in considering her ideas about food for the grown plant. The discussion led her to add fertilizer and plant food to her list of foods for the grown plant. Tiffany's interruption also led to an interesting elaboration in Michelle's journal entry:

Tiffany: I've got an experiment to explain.

KR: Oh, good.

Tiffany: Take the whole bean. Water the whole bean. Everyone gets their own, so it'd be easier to look at. The next day cut the whole bean open, or whenever you said it was getting sugary. And then look for the sugar in the cotyledon.

KR: To see if there's sugar in the cotyledon?

Tiffany: Yeah, to see where it's at. And maybe bring a magnifying, those little things . . .

KR: Tiffany, I think we could do something like that . . .

Tiffany: Cause I don't understand what you mean by sugar . . .

KR: I'll see if Mrs. Hazelwood has some extra beans from our experiment because I think we could do something like that. That's a great idea.

Tiffany: (to Heidi) That's gonna be fun. Cause you could see where it's at.

Michelle: That's a good idea, Tiffany.

Tiffany: We'll need magnifying glasses. Didn't Mrs. Cane have some awhile ago?

Tiffany's journal entry:

2. the water is good because a grown up bean gotr sugar

1 I don't think the emorde [embryo] get food from water. It needs the condelede [cotyledon] Because the condeleded got the suger

Questions

3. Can we do exment [experiment]. About it.

1. Take a whole bean (eveyone get there own) water the whole bean
2. The next day cut the whole bean open
3. look for suger

Tiffany, a student who had been held back a grade and who received Chapter 1 reading support, was generally silent in class. These mini-conferences provided important glimpses into her thinking. In this case, it was clear that she was genuinely puzzling about my claim that there is sugar stored in the seed's cotyledon. She had looked at bean seeds in our experiment and did not remember seeing sugar there. So she took the initiative to propose an experiment to further explore her question. This gave me an important hook to getting Tiffany more involved in our classroom. I chose to ignore her responses to questions 1 and 2 and focus instead on her question: Where is the sugar in the cotyledon? Michelle overheard the conversation and by the end of the writing period, she too had developed plans for an experiment around a question that interested her. She wanted to see if the bean experiment would turn out differently if it was done in cups of moist soil (instead of on moist paper towels):

Michelle's completed journal entry:

1. I don't think water is food for the embryo alone beacuse in the bean experament water didn't help the embryo grow.
2. I think water, fertilizer, and plant food help a grown plant grow. because it helps it grow.
3. Does fertilizer help plants grow?

Experement

take 4 bean seeds home
take 4 cups of soil home

put whole bean in one cup
put embryo in one cup
put cotyledon in one cup
put cotyledon with embryo in one cup

Would the whole bean, cotyledon, embryo, and cotyledon with embryo all grow in the soil?

In this writing task, I determined specific questions to guide student writing but structured it in a way that encouraged student questions and in this case enabled Tiffany and Michelle to propose activities that they would later carry out and write about with support from me during recess periods. My conference responses were individualized but were focused on helping each student develop a better understanding about two of our curriculum strands: how plants get their food and the nature of scientific inquiry. I wanted to minimize the writing demands of the task so that students could focus on using writing as a tool for thinking. My suggestions for writing changes focused on helping students clarify their ideas rather than on improving the quality of their written text. The writing at this point had a limited audience--the students were writing for themselves (to clarify thinking) and to me, to help me understand their thinking. In these ways my role stood in contrast with Rosaen's role in writers' workshop.

Making Writing Public and Shared

For many students it seemed important to be able to try out their ideas with me privately before feeling safe to share them publicly with the class, our larger audience. In the next segment of the lesson, ideas first tested out in private in the journal writing became part of the public domain both through discussion and through writing on our Hypotheses Chart:

KR: I'm so excited about what you're writing. And the questions that people are coming up with; many of these questions, as we continue doing our experiments, I think we're going to be able to get some answers. Maybe not all the answers to everything, because scientists are always trying to figure out more and more. A lot of people . . .

Matt: I've got six questions down!

KR: You've got six? OK, what I want to do is see if we can add some little yellow stickies to our chart of evidence, and we're talking now about water. This one, "Is water food for plants?" What about number one? How many people said that water is not food for the growing embryo? OK, so quite a few people. Would someone give some good evidence for that position? Let's let them write that idea on a yellow stickie and put it up on our chart. So would everyone listen to the contributions people make and decide if you think that's pretty good evidence? So we're looking for evidence that water is not food for the growing embryo. Mike?

Mike's journal entry:

1. No not really mostly is't the sugar in the coteledan
2. Yes because they don't have not more sugar to grow
3.

Mike: No, not really, mostly it's the sugar in the cotyledon.

KR: He said, no, it's not, because mostly it's the sugar in the cotyledon that's food for the embryo. What do people think? Is that a good reason?

Students: Yes.

KR: OK, Mike, why don't you put that up? Who has something to add or something different? Put your name and the date on the stickie also.

By having students write their ideas on stickies with their names and the date, I was encouraging them to have ownership of their ideas but also to keep track of how their ideas change over time. In contrast with the writers' workshop emphasis in revision of ways of communicating ideas in writing, my emphasis was on revising ideas. I wanted to create an environment where it is safe to have an idea made public and later discounted in favor of a better explanation; I encouraged students to feel good about contributing ideas that helped the group in thinking about the problems. As the public conversation continued, I was pleased to hear from both Russell and Nan, the two students whom I had worked to involve in the conversation in the lesson described earlier. Both Russell and Nan drew from what they wrote in their journals but unlike Mike did not feel compelled to stick to the script of their own written text; instead they use the conversation to extend the thinking they had done on paper:

> Russell's journal entry:
> I think water is food for the embryos because if the water didn't soke into the cotyledon then it wouldn't be abele to soke into the embryos because it would be shriveld up then the embryos couln't get the energy (sugar) from the cotyledon but, the have to be atatched to each other or they will not grow.
>
> it's kind of the same like number one but, the plant mostly needs the sun.
>
> 3. How can the sun be food for plants?
> Is there a large variety of food for plants?

Russell: Well, I want to say something about Mike's saying that he, in his thing, he said "mostly." What's the other thing that he meant?

KR: Oh, do you have an idea? You [looking at Mike] said mostly it's the sugar in the cotyledon. Russell, what are you thinking about that?

Russell: I don't know, maybe there's something else.

KR: Maybe there's something else in the cotyledon?

Russell: He said "mostly."

KR: OK. Russell has a good question for us to be thinking about, and I like the way he was listening very carefully to what Mike said. He picked up on that he said "mostly." Nan?

Nan: I said that it isn't water for the embryo because the evidence is water isn't food for the , wait, ok, water isn't food for the embryo because water, because it has, I think water, it was water, it was food for , if water was food for the embryo, then it would've grown.

Despite her starts and stops, Nan eventually got out a clearly reasoned idea: If water was food for the embryo, she reasoned, then why didn't the detached embryo grow when it was given water? Nan was a student who wrote in her journal on the first day of science, "I hate science," and she told me in an interview that she was not good at science. Yet here she was volunteering to puzzle publicly through her ideas about the relationship between water and plant embryos. The conversation continued as we considered together the role that water plays for grown-up plants. Again, Russell was a key player in the discussion, contributing an idea that got everyone thinking about the sun as a factor in food for plants. His idea clearly grew from his experiences exploring desert plants in the adaptations curriculum strand:

> I think it's [water] not [food for plants] because . . . I think it just needs it [water] to keep moist because if you think about plants in the desert, all they need is just to keep moist. And they use mostly the sun.

When we had exhausted the students' ideas and represented each of them on yellow stickies on our hypotheses chart, I concluded this portion of the lesson by calling attention to the students' use of evidence in supporting their ideas:

> We've got so many pieces of evidence now that we ran off the board and onto the wall! That's terrific! And if you guys listened to what you were doing today, the kinds of evidence that you're giving today are much, much better than you were doing at the beginning of the year. You're really thinking.

The Teacher's Role in Encouraging Ownership and Revision of Ideas

A few days later, we were considering the hypothesis that soil is food for plants. The way that writing was used in this lesson illustrates the emphasis that was put on ownership of ideas (Sheila's idea, Russell's idea, Matt's idea, Nathan's idea etc.) and on revision of ideas based on convincing evidence. The teacher's responses to students' writing both orally (privately and in group discussions) and in writing seemed to play a key role in fostering students' willingness to contribute their ideas in the public forum.

KR: Yesterday we were talking about whether or not soil or dirt is food for plants. And this was the evidence that we came up with yesterday. Some of the ideas you people had about whether it was or not. I want you to be thinking about these pieces of evidence and then to start off today, I'd like each of you to write in your journal, for today, what you think about this question: Is soil or dirt food for plants? And what do you think is the *best* evidence? Some evidence is better than others. So what do you think is the most convincing evidence to support your position? So some of the reasons that people gave yesterday [reading from chart] were "yes, soil or dirt is food for plants because the white foamy things in the soil might have energy in them." Someone else suggested, Matt, suggested that it might be food for plants because worms eat dirt, and so he thinks dirt must give energy to worms, and some people agreed with him on that. People who were giving evidence that no, soil or dirt is not food for plants, I think it was Sasha? said soil is just for the roots to hang on to, it's not to give them food. Another reason given yesterday was that--our bean seed experiment, we did it without any soil. And some of the beans with the embryos, with the cotyledons attached grew without soil, so that seems to be evidence that maybe soil is not food, they don't need *it* for food. Someone else said that soil is not food for humans. We said babies, people don't eat dirt, it doesn't give us energy, so it must not be energy for plants. And then some else said . . .

Matt: Russell said that.

KR: Russell, did you say that you disagreed with Matt about the worms?

Russell: Yeah, cause it's probably the stuff in the soil.

In this introduction, I tried to acknowledge and value each student's contribution to the list of ideas while also encouraging students to evaluate the evidence proposed and consider that "some evidence is better than others." The writing task was designed to move students a step beyond the valuing of all ideas towards more critical thinking. As the students wrote, I circulated among them, responding to their writing individually. An interaction with Nathan, a student who was typically invisible and silent in the classroom, became important in pulling Nathan into our scientific learning community:

> Nathan's journal entry:
> Yes I think it is because I measure my soil and win the plant grow the soil went down. a little and I think the white foamy thing are food.

KR: Oh, are you talking about the grass plants? [Each group of students had planted grass seeds and watched their progress growing in the light and in the dark. Nathan had also taken some grass seeds and soil home to do an experiment of his own.]

Nathan: Yeah.

KR: Did the soil level go down?

Nathan: A little. Not that much.

KR: OK, how come you didn't share that idea with us yesterday?! That's a good idea! You observed that, that's good evidence.

Shortly after this interaction, the class began reading about Jean Van Helmont's experiment back in the 1600's. Van Helmont placed a tree in a tub of soil and carefully measured the weight of the tree and the weight of the soil. I asked the students to predict what would happen to the weight of the tree after five years, and there was unanimous agreement that the tree would gain weight. When I asked what would happen to the weight of the soil after five years, Nathan volunteered and shared from his journal writing his prediction that the weight of the soil would go down:

KR: Someone who made that prediction--why do you think the weight of the soil would go down? Nathan?

Nathan: Cause in the plants, the grass plants back there, I measured the soil when we first planted them, and it went down one-tenth of a centimeter.

This was one of the first occasions on which Nathan volunteered to participate in the group discussion, and I attributed his willingness to speak at least partly to the private encouragement I had given him in our mini conference during the writing period. I also heard from two other typically silent students, Nan and Tiffany, in this interaction. Tiffany's response elaborates what she wrote in her journal, adding a reason why she cannot imagine soil as being eaten by plants. Nan's response represents new thinking that contrasts with her written claim that soil *is* food for the plants. Nan's idea is enthusiastically received by at least two other students in the class.

> Tiffany's journal entry:
> Yes because the white foamy things might have energy in them
>
> Nan's journal entry:
> yes I think soil is food for plant becous the litter [little] foamy thing that are in It and the moiest [moisture].

Tiffany: See, if you plant a tree, it doesn't have no mouth or anything, so how can it eat something, if it has no mouth?

Laticia: That's what I'm wondering.

Tiffany: And the tree, how's the, how's the dirt supposed to go up in the tree? It has nothing to eat it with.

KR: OK, so the tree couldn't eat like the soil. Does anybody disagree with Tiffany about the tree couldn't eat the soil because it doesn't have a mouth? John? I'll get to you Nan, let me . . .

John: I think that it has a way of eating it through its roots up in its trunk.

KR: OK, so we've got a difference, different ideas going here. Some people predicting that it couldn't eat the soil, because it, like Laticia and Tiffany say, it doesn't have a mouth. But John and others are saying that it could somehow get the, get it up through the roots. OK, other people who said the weight of the soil would stay the same? What was your reason? Nan?

Nan: I think it would stay the same because you know the, the plant, I mean the soil doesn't just disappear, so why wouldn't it, why would it be different than it was when you first planted it? How would it get away? Cause I don't believe the plant, I don't think the plant eats the food. And if the plants doesn't eat the food, then where does the soil go?

KR: And you don't think the plant eats the soil?

Nan: Yeah. And then if it's, and then if it did go away, and if it didn't stay the same, then where would the soil go?

KR: OK, so if you look out on the playground, Nan, are you thinking about, like there's grass out there, but the soil doesn't disappear?

Nan: Yeah, cause if the soil . . .

KR: And if the grass was eating--hey, I kinda like that idea: If the grass was eating the soil, the soil would all disappear?

Student Put it up there! Put it up there at "soil."

Heidi: Or else our world would go . . .

KR: OK, do you want to put that down as an evidence? Let me see if I can find my little yellow stickies!

One important purpose of the writing task was to stimulate a discussion that would challenge students to reconsider and revise their ideas. It seems that Nan is caught up in that process in this interchange; something in our discussion led her to develop an argument that contradicted what she had written in her journal about soil being food for plants. And even though it was a big day for Nathan in finally sharing his ideas publicly, his ideas were not left unexamined and unchallenged. Like all ideas put on the table, his also received critical examination which I tried to handle in a way that showed the ideas were worthy of our time and consideration even if the ideas were criticized for failing to completely explain the phenomena at hand:

Keri: Well, what Nathan said, he measured it, but when it gets wet, it goes in, but then that packs it down, and then people go over there and touch it to see if it's all wet and stuff, to water it. So that's how it [the soil level] probably went down.

KR: OK, Nan and Michelle, are you listening to Keri's observation? Nathan, does that make sense to you?

Nathan: Yeah.

Matt: Dr. Roth, we're gonna have to start going onto the wall again! [Our stickies were overflowing the bulletin board on which we hung our evidence chart!]

KR: OK, that's fine. I kinda like going onto the wall, I think that's fun.

Matt: I started it! That's two times I've started it.

KR: Keri's kind of responding to Nathan's idea, that there might be other reasons why the soil in his grass plant experiment went lower. Maybe it was just cause it got, people touched it and matted it down, or maybe because it got watered.

In this exchange, Nathan's idea was both valued and challenged, and there was a group celebration that our ideas about evidence to support and refute hypotheses were overflowing the chart on our bulletin board. The lesson continued with students reading about what actually happened in Van Helmont's experiment (the soil did not lose weight) and working in pairs to construct explanations about the question, "Is soil food for plants?" In introducing this group work, I reminded students to consider both the evidence presented by classmates and the evidence from Van Helmont's experiments to reconsider their position regarding soil as a source of food for plants. Interactions between Heidi and Michelle show how students were beginning to internalize a way of interacting and negotiating about ideas without the explicit intervention of the teacher. I found it striking that for Michelle and Heidi my role in this interaction was limited to assigning the task and letting them work on it. I was pleased that their work together resulted in an unassigned written product to share with the class in our "Question Notebook":

N: [reading] Think about our scientific definition of food. Is soil food for plants?

M: Because the soil helped it grow, Heidi, the soil helped it grow, but it didn't gain any weight, the soil didn't lose any weight. You should write, "The soil . . . "

H: I don't understand what you mean. What are you getting to?

M: I said "no" because the soil stayed the same.

H: Um-hm.

M: It just stayed the same weight. The tree grew.

H: So what do, how do you think the tree got food though? Do you think the water is food for it?

M: I think the little foamy balls in the thing [soil] are. You don't understand it, do you?

H: Yeah I do.

M: You sort of explain how, say what you're thinking of what it should be.

H: OK, well, I think "no," too, because if it doesn't make the tree grow, then I don't think it will . . .

M: Will help it grow.

H: . . . Will help it. And if the soil doesn't go down, it's not eating it for food. But. . .

M: We know it's "no," we know we think it's "no." We can put "no."

H: But why? We have to figure out, we gotta figure out a way to put our, our, our reasons together.

M: Well, because . . .

H: Why? Why do you think? I mean, why, how can we put our ideas together? 'Cause they're both good ideas, I think.

M: "No," because, like, you said how it didn't need it. How could this tree grow if it didn't eat the soil? Hey, that's a good question!

[Heidi and Michelle go over the class Question Notebook and enter into it the following entry:

Michelle 11-20-90

How would the tre grow without the soil?]

H: So how are we going to make that into an answer, Michelle?

[See Figure 1 which shows how the two girls wrote down their ideas in the Food for Plants text]

KR: OK, let's have everyone back in their seat. Now, in your journal, right underneath what you wrote earlier today, I'd like you to write a sentence that starts like this [points to board]: Based on evidence from Van Helmont's experiment, I think . . . You can say "I think soil is or is not food for plants because" or you can say "I think what I had down before was right, " or "I think what I had down before was wrong," or whatever you want to put. But give a reason!

The highly structured nature of this writing assignment was designed to encourage students not only to feel ownership of their ideas but also to be open to changing and revising their ideas on the basis of new evidence. Studies of students' learning in science classrooms have revealed how difficult it is for students to change their ideas, and I felt I needed to make that expectation explicit as a goal for the students. The students wrote their current thinking right underneath the writing they had done at the beginning of the class period; they were encouraged to either support or change their earlier thinking. After the students wrote, the class was excused for lunch, and I went around and wrote brief responses to each student's writing (my responses are represented in italics below). Overall, I was pleased that the writing revealed students' willingness to change their minds in light of new evidence:

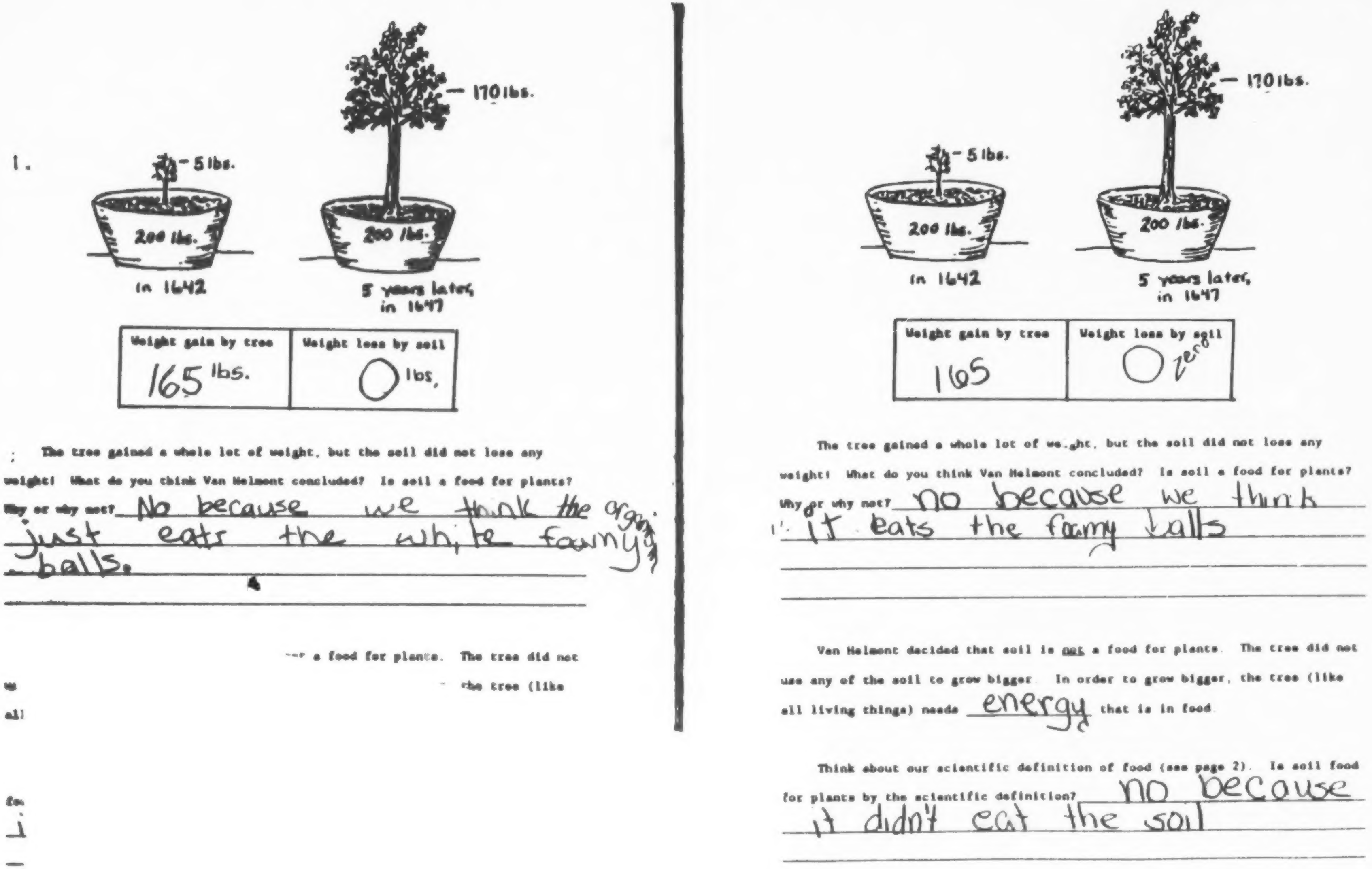
> Nathan's completed journal entry:
> yes I think it is because I measure my soil and win the plant grow the soil went down. a little and I think the white foamy thing are food.
> Based on evidence from Van Helmont's experiment, I think my anwnswer was wrong because it might of been the water prsher
> ***You are a good scientist! You were very sharp to observe the soil level! Dr. Roth***

> Heidi's completed journal entry:
> yes I think that soil is food for plants because I think the white foamy things give them energy.
> Based on Van Helmont's experiment. I think soil is not food for plant just the white foamy things are.
> ***Do you think Van Helmont had white foamy things in his soil? Dr. Roth***

> Nan's completed journal entry:
> yes I think soil is food for plant becous the litter foamy thing that are in It and the moiest.
> Based on evidence from Van Helmont's expeamunt I think soil is not food for plants.
> ***Nan, Can you add a reason? You're a good thinker!***
> ***Dr. Roth***

> Tiffany's completed journal entry:
> Yes because the white foamy things might have energy in them.
> Based on evidence from Van Helmont's experiment I think no because nother of the soil's wethg [weight] gose into the plant
> ***Super job--good thinking! Dr. Roth***

The students were captivated by the little white foamy balls in potting soil that you buy from the store. Although Nathan was clearly pleased with my enthusiasm about his observation about the soil level of the grass plant pots, his revised response shows a willingness to reconsider his idea. His response reflects his consideration of Keri's ideas that there might be other factors that could explain why the soil level went down ("water pressure" was his guess). My written response to Nathan was


1.
5 lbs.
170 lbs.
200 lbs.
200 lbs.
in 1642
5 years later, in 1647
5 lbs.
170 lbs.
200 lbs.
200 lbs.
in 1642
5 years later, in 1647

Weight gain by tree	Weight loss by soil
165 lbs.	0 lbs.

The tree gained a whole lot of weight, but the soil did not lose any weight! What do you think Van Helmont concluded? Is soil a food for plants? Why or why not? No because we think the organi just eats the white foamy balls.

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Weight gain by tree	Weight loss by soil
165	0 zero

The tree gained a whole lot of we.ght, but the soil did not lose any weight! What do you think Van Helmont concluded? Is soil a food for plants? Why or why not? no because we think it eats the foamy balls

Van Helmont decided that soil is not a food for plants. The tree did not use any of the soil to grow bigger. In order to grow bigger, the tree (like all living things) needs energy that is in food.

Think about our scientific definition of food (see page 2). Is soil food for plants by the scientific definition? no because it didn't eat the soil

Figure 1. Pages from Michelle and Heidi's Food for Plants text: Ideas about soil.

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celebratory and designed to encourage his continued participation in the public sharing of ideas.

Heidi's response also shows new thinking; she was now clearly distinguishing between soil and the white foamy things *in* soil. My response to her pushed her to think about how the evidence from Van Helmont's experiment could be used even more fully to support her idea and to raise new questions for her to consider: How did Van Helmont's tree eat if it didn't have the white foamy things? Nan's written response did not convince me that she had really changed her mind, and I pushed her to provide evidence for her statement. Was she saying what she thought I wanted to hear? Or was she thinking about the idea she shared in class about the observation that soil (in the world, on the playground) doesn't disappear?

Despite successes in this highly structured lesson to get students to be open to new evidence, a few days later I was frustrated that students once again did not seem open to changing their ideas. Prior to presenting the idea of photosynthesis, I asked the students to write about their current ideas about food for plants, their evidence, and a description of the ways their thinking had changed "so far." I was disappointed that the students were unable to write about how their ideas had changed. Instead of proceeding the next day with the planned lesson on photosynthesis, I used the knowledge I had gathered from this disappointing writing to structure a writing task that would again focus attention on the importance of revising ideas:

KR: Yesterday, the last thing we did, was I had you write in your journals about taking the vote [about what is food for plants]. And then I asked you--Did you change your mind about anything? And I've been seeing such good writing from you guys lately, but yesterday when I looked at that question, I was really disappointed, because--I couldn't figure out--I was sort of expecting people to put things like, to be really good, thoughtful scientists and write down things like--well, when we took the vote the first day I thought that um . . . what was something you thought the first day was food for plants? Jesse?

Jesse: Um, fertilizer.

KR: OK, "On the first day, I thought fertilizer was food for plants but"--then I was expecting to see things like, "Now I'm not so really sure because when we looked at the plant food container it didn't have any calories in it, It didn't have any energy or sugar in it." I was expecting to see more thoughtful answers. Things that you, good scientists when they get evidence they reconsider their ideas, they're willing to change them. And I thought so many people just said: "I think the same thing." So I got puzzling about that and trying to figure it out--just like a good scientist.

One thing I was thinking was maybe the reason you didn't do as good writing on that as I was expecting was maybe you forgot what you had said at the beginning. That's why I have your yellow sheets back, which are the pretests you took about plants and food for plants. Look at what you wrote for #2. The question was: Describe what food is for plants. That was back in October. Look at what you wrote. [Pause while students read, some giggle at what they wrote]

OK, now what I'd like you to do is in your journals, I want you to write to me. Just like if you were talking to me after class or at recess time, about whether your ideas have changed or not and why.

Class: Do it over again?

KR Do it over again. You might start one of your sentences like this [points to board] "I'm still wondering about . . ." or "I'm still confused about . . ." or "I'm not sure about . . ."

As the students wrote, I wandered the room reacting to students' writing and posing questions to them individually:

- Did the white balls give food to the plants? What are you thinking now?
- Do you still think the white balls are food for plants or are you confused or not sure about that?
- Why don't you add that to your answer? That's good.
- OK, can you tell me now why you are wondering about that?
- Have you changed your idea about fertilizer? Could you explain how you've changed your idea?
- Could you explain how you've changed?
- And why does that prove that water is food?
- Is that different than what you thought before?
- What about dirt? Have you changed your mind about dirt?
- And what about the sand? You think that's just not right, and what's your evidence?
- What about Van Helmont's experiment?
- It sounds like you're confused about soil.
- Why don't you put that down?
- OK, so when you say it is "a certain thing," it's not just anything. And that's what you had before--you mean anything? What does it have to have in it? [sugar] Oh, why don't you add that?
- Could you tell me, add right there, why you are confused.
- And when you say liquids, you mean any kind of liquids--water, juice?

During this writing period, my interactions with Laticia ended with her raising a question that I found to be particularly significant:

> Laticia's journal entry:
> Dr. Roth, I did a horrible job when I put the word sand on my paper. And this is what I wrote: Water and sand. Ha, ha, ha. Because the water helps it grow and to make you grow (what a laugh) you have to eat it (what a laugh)

KR: OK, explain how you've changed your mind about dirt. And what about the sand? You think that's just not right--and what's your evidence?

Laticia: Evidence about sand not . . . because, I don't know. I think that the last, I don't think sand is [food for plants]. I think soil or water is.

KR: What about Van Helmont's experiment?

Laticia: He didn't use sand; he used soil.

KR: Oh, you just said "soil" though.

Laticia: When we did the light, it [the grass plants] had soil and it grew and it had water, too.

KR: It sounds like you're confused about soil.

Laticia: And water.

KR: So, why don't you put that down?

Laticia: Is sun food for plants?

> Addition to Laticia's journal entry:
> I'm still wondering about water, sun, and soil, because the one in the dark grew and it had water and soil.

Because sun was going to be a critical piece of the explanation of photosynthesis, I decided to highlight Laticia's question, "Is sun food for plants?" in the public domain to encourage students to consider this question using evidence from our grass plant and bean seed experiments. I also used the occasion to make explicit the role that I thought writing could play in developing ideas. Although many students were pondering this idea about the sun in their writing, I chose to present the idea as Laticia's because I knew she was struggling to fit into this classroom as the only Black student who had just recently moved into our community from a nearly all-Black community:

KR: Oh! We have a good question here! Let's come back together as a group right now. As Laticia was writing--sometimes this happens when you are writing and thinking about your ideas, you come up with some new questions and realize you are not sure about some things. What was your question, Laticia?

Laticia: Is the sun food for plants?

KR: Is sun food for plants? That's what she started thinking about and I think I saw that on several people's papers. They are really thinking about the sun right now. Because of the experiments we've done. The sun seems to be very important. Laticia, would you be sure we get that one in the Question Book? Um, Mrs. Oren, do you have the Question Book?

Oren: It's right here.

KR: Oh, Michelle's got it. OK, when she's done . . .

The completed page in the Question Book that week included two questions that Michelle had privately entered on her own along with Laticia's question that I had highlighted in the discussion. Later in the week, Laticia added two more questions on her own:

Michelle 11/29/90
How could plant food be food for a plant if it doesn't have calories?

Laticia 11/29/90
Questions: Is sun food for plants?

Michelle 11/29/90
How can soil be food if a plant only eats the white balls?

Laticia 12/4/90
Is sun energy for plants?

Laticia 12/4/90
Does the plant have more than one baby plant inside?

I also chose to highlight Matt's writing in the public discussion, because he had an idea that I thought might provoke others to reconsider their entries:

KR: I saw, I don't know, I think I read everyone's and on Matt's, he wrote something that I don't think anybody else had. Read your answer, Matt.

Matt: I think sun is food for grown-up plants and cotyledon is food for a seed.

KR: Did anyone else put cotyledon for a seed? [pause] Does anybody else agree with him that the cotyledon would be food? How many people agree that the cotyledon would be food for the embryo? [many hands raised] OK, let's add cotyledon to our list [class chart of hypotheses]. We don't have it up there, do we?

Class: No.

I deliberately chose to highlight ideas that would push students to consider scientifically accepted ideas about food stored in cotyledons and that would prepare students to make sense of the scientific explanation of photosynthesis. Although I drew from students' writing to raise these questions, I played a central role in deciding which ideas would be highlighted in the group forum. I made a judgment based on the students' writing that many of them were ready to explore more fully the role of the sun in plants' getting of food. By making that question an explicit part of our discussion, I hoped to raise students' awareness of the sun issue and to heighten their readiness for the explanation of photosynthesis. And yet I wondered if I was being too controlling and authoritative. Was I truly honoring students' voices or was I manipulating them?

Celebrating Revised Ideas and Shared Understandings

Overnight I responded in writing to the students' journal entries, hoping that my responses would encourage them to continue to puzzle over the questions and to participate fully in our scientific community:

> Nan's journal entry: .
> Dera Dr R My ides have chandgd alot I said wather I do not now whot is food for plants but I think wather is food for plants and plant food. Why wond the call it plant food if it isnt food. from Nan
> ***Nan, Listen really carefully to the new evidence we get next week. I want you to really think carefully! Good job today. Dr. Roth***

> Michelle's journal entry:
> I'm still confused about plant food and soil because how could plant food be food for the plant if it doens't have calories? How could soil be food if a plant only eats the foamy balls?
> ***Michelle, This is excellent thinking! You've asked some really good questions! Dr. Roth***

> Roberto's journal entry:
> I am confused [about] thea bosl lidol wiet bose [the balls little white balls].

Roberto, We should call a plant store and ask them what the white balls are! Dr. Roth

Russell's journal entry:
I still think food for plants are liquides bercause without liquides it would die. Sun because it would grow then die.

Matt's journal entry:
Dear dr. Roth My Idea have changed allot I guess I think that sun is for a grownup plant and a cotyledon is food for a seed. I not sher about those white foamy things.
Matt, I'm glad you remembered about the cotyledon--no one else brought that up but everyone agrees! Dr. Roth

Nathan's journal entry:
Dear Dr. Roth I'm still suher fertilzer is food for pants because it gives it energy. I also still think sun is ofood for plants because of the grass plants the ones in the dark were yellow and the ones in the light are green. But I still not shere that sun is food for plants because I thank that they did not have enough air to live so it turned yellow.
Nathan, Super job of explaining your thinking! Dr. Roth

Laticia's journal entry:
Dr. Roth, I did a horrible job when I put the word sand on my paper. And this is what I wrote: Water and sand. Ha, ha, ha. Because the water helps it grow and to make you grow (what a laugh) you have to eat it (what a laugh) I'm still wondering about water, sun, and soil, because the one in the dark grew and it had water and soil.
Laticia,
You didn't do a horrible job before! It's just that you've learned some new things! I'm proud of your progress in science! Dr. Roth

I started the next day's lesson by having students look at their entries and my response, and by encouraging them to make any last changes or additions prior to our "vote." The vote was something we did periodically during the unit to assess the class's views about our different hypotheses about how plants get their food. Today's vote would be followed immediately with a lesson in which students would read about photosynthesis for the first time. Prior to taking the day's vote, I encouraged students once again to reconsider and revise their ideas:

Roth: OK, we're going to take the vote now. But before we do would you look at what you wrote down yesterday? I want you to only vote for those things that you

> think provide food energy for plants. And if you want to add anything that you didn't put down yesterday, add it to your list right now. Like if you want to add cotyledon, add it right now. We are going to take a vote today, it's November 29th.

As we started the voting, the students negotiated for a new category of voting--a "half" vote to represent "unsure." I accepted this proposal, stating "Let's allow for unsures because scientists are unsure, right, so it's allowed." It took quite a while to go through our long list of hypotheses, and although there were many changes in the voting pattern from the first day we had constructed the chart there was no emerging pattern of consensus until we reached the end of our list:

KR: How many people think cotyledon is food?

Class: [All hands are up]

Students: Everybody in the class!

KR: All right, we all agree on something!

Class: [Many cheers of self congratulation]

This was a moment of celebration in our joint construction of meaning. Like a scientific community we had spent long hours exploring a problem and were now reveling in at least one shared conclusion we had reached. Although it was clear that there were still many areas of questions and uncertainties about our various hypotheses, everyone shared in the understanding that the cotyledon provides food for the growing embryo. This was a new idea for everyone in the class; no one had mentioned this idea on the pretest. This moment was one of shared learning and growth, and no one was left out.

Analyzing the Teacher's Role: What About Students' Learning?

My description of the role I played in supporting students' writing and thinking in science illustrates clear differences from the role that Rosaen played in writers' workshop. As summarized in Table 3, the writing tasks I assigned in science were carefully structured by the teacher and involved much less student choice than the writing done in writers' workshop. The purposes for writing were limited to "thinking on paper," using writing as a tool to help students revise and reconsider their hypotheses and explanations about a shared problem: How do plants get their food? The students did not choose the problem, and the students did not choose the form or topic of the writing tasks. Students' ideas captured in their writing were challenged as well as valued. Students were encouraged to change their ideas based on evidence and sound argument. In contrast with their writing "All About Me" in writers' workshop, students in science were not considered to be the final authority, the expert, regarding ideas about how plants get their food. Their ideas were expected to change and to be in line with evidence and the growing consensus of the class based on that evidence.

My relatively authoritative role in science gnawed at me as I watched students flourish in the choices they were given in writers' workshop. Should I change my role in science? Should I allow students to choose their topics of study? Should I be less structured in assigning writing tasks? An examination of students' learning in science helped me analyze and consider certain strengths in the role I played in supporting students' writing to learn.

This study of students' learning convinced me that these students had developed some understandings about photosynthesis and plants' food that were unusually deep and long-lasting. Their incoming ideas about plants were challenged, and the new ideas they developed seemed to become part of their way of thinking about plants rather than memorized definitions quickly forgotten. Table 4 shows how students' ideas about plants changed in significant ways across the unit of study (Nov.-Dec. 1990). Although this data draws primarily from direct questions, such as "How do plants get their food?" the students' answers to more application-oriented questions show that they could use this knowledge to explain phenomena that had not been discussed in class (see Table 5).

Table 4
Students' Conceptions About Food for Plants Across the School Year

STUDENT	PRETEST, OCT 90 Describe what food is for plants.	POSTTEST, DEC 90 Describe what food is for plants.	MINI-INTERVIEW, DEC 90 Use these words to create a word picture that makes sense to you. (I = Interviewer) Explain your word picture.	INTERVIEW, JUNE 90 What was something you studied in science this year that you understood really well?
NAN (N)	They is wonter and cun [water and sun]	food for plants is sun air water mixs together makes food for plants	N: What I meant was water, sun, and air mix together for food. The water starts off in the leaf and then it goes to the stem and then the tubes, and then the roots. I did it kinda wrong. The sugar in the cotyledon it starts off in the cotyledon, in the embryo, because that's the seed, and then it goes to the leaf the stems the tubes. I: When you say "it" what do you mean? N: The water and the sun—the food for the plant. It starts off in the cotyledon, and then it goes to the leaf the stem and the tubes and the roots and this is that it mixes together. I: These three things - water, sun and air—mix together? N: Yeah, to make food for plants. And the scientists have questions about food for plants.	I: Is water food for plants? N: Not only water. I: What else is food for the plant? N: Sun, air, and water mixed together. I think that's the right words, isnt' it? I: Yeah, so sun, air, and water mixed together . . . N: Is food for plants. I: And where does that happen? N: In . . . I forgot. I: Is it in something? N: I think it is inside the plant. I: So it happens inside the plant somewhere. After the plant mixes those three things together . . . N: It's in the roots and it goes up the plant and gives the plant water. I: It gives the plant water? N: I mean food. I: Did you know this before science this year? N: No. I thought that people water them and it would go into the soil and the plant would suck it up.

Table 4 cont'd

TIFFANY (T)	sold frdalider plant spara [soil fertilizer plant ?]	The colytedon [cotyledon] and affer that is gone it use it own food it makes it out of sun, water and air	T: The seed gets planted in the soil. Then the embryo eats off the cotyledon, then that gets all gone. Then the leaf . . . the food gets made in the leaf now. It gets air in the holes and the air they use is carbon dioxide. And then the chlorophyll gets the sun. The sun comes in, and then the roots get the water. And then it turns into sugar and the sugar is food and that's called photosynthesis. Store-bought food, like fertilizer, minerals, doesn't have energy. Structures like tubes, fruits, vegetables, stems all have functions. Scientists try to find things about about plants and animals.	T: How the cotyledon grows or how the bean seed works. I: Why don't you tell me something about that? T: The cotyledon eats, well, the embryo eats off the cotyledon when you plant it. First you have to plant it. When it gets wet, the cotyledon turns into sugar. Then the embryo eats the sugar. Then when it grows it does that and when it grows enough and the cotyledon is all gone, then the cotyledon falls off kinda. It gets air from the little holes. T: It gets air from the what? T: The little holes in the plant. And wherever it's green that's chlorophyll and that's where the sun comes in and it gets water from its roots, from people watering it or like when it rains. I: If the cotyledon is gone, where does the plant get food? T: Oh, I didn't say that part, the air, sunlight, and water mix together and makes food. Well, [it] is the food actually. I: OK, so is the air also food? T: Um huh, but they all got to mix together.

Table 4 cont'd

NATHAN (N)	the food is soil and dirt	Sun, Air and water but not alone it needs to mix	N: Air, sun, water mix to make food for the plant. The stems, tubes get air for the plant. Roots collect the water, and these are photosynthesis. I: Point to what you mean by "these." N: Points to air, water, sun. The seed's plant [embryo] does not have chlorophyll in the leaf and the cotyledon is food and energy for the embryo. Scientists ask questions about vegetables, about how the vegetables get food. Animals and fertilizer is not food for plants. . . . The plant don't really need em to make food, but they do need em.	Photosynthesis is sun, light, and wait . . . sun, air, and water mixing together in the plant and it takes em all in and makes food out of em, and it either stores the food or eats it. T: Tell me how it stores the food. N: In the leaves and stuff there are little things that take and store stuff in and it eats it when it's hungry. T: Where, or how does it eat it? N: I don't know, I think it just goes around the plant then goes into the tiny cells that are in it. I wonder how they figured out about that! Then they get together and make photosynthesis which is food for the plant, and then the plant stores it and eats it like that . . . T: Would you say that air, sun, and water are food for plants? N: Alone they are not, but mixed together they are.

Table 4 cont'd

ROBERTO (R)	The white lido bose [little balls] give it fude to the plant	cotyledon	R: The seed gets water. Sun shines on the leaf. Air goes through the leaf and goes back up here. The cotyledon gets, gives food to the embryo. I: What happens to the embryo as it gets food from the cotyledon? R: It gets bigger and bigger and bigger. I: What's in the food that it's using to grow? R: Sugar . . . it has energy. I: Does the embryo eat the cotyledon forever? R: No, the cotyledon falls off when it doesn't need it anymore. And then the embryo gets bigger and it makes its own food. I: How does it do that? R: The water, air, and sun mix into the leaves and makes sugar. I: What does the plant do with the sugar? R: Eats it. Stores it in the vines.	I: Tell me something you learned about plants that you didn't know before. R: They need air, water, and sunlight. The sunlight goes onto the leaves and comes to the roots. So does the water and air, and they mix and make food for the plants. I: What happens when a plant, like a bean seed, first starts to grow? R: The cotyledon grows and when the cotyledon gets its food from the embryo. . . . Wait, is the embryo the little thing inside it? I: Yes. R: The embryo gets the food from the cotyledon and the embryo grows and when it is fully growed and gets leaves the cotyledon falls off. And then you need water, air, and sunlight.

Table 4 cont'd

MICHELLE (M)	a special thing like a stik but only it is plant food	air, sun and water mixed together	M: The air, the sun, and the water mix together and make a sugar. Food energy for the embryo is in the seed. The embryo is a tiny little seed before it starts. Chlorophyll makes plants green. Plants, tubes, leaves, stems and roots all go together, they're all structures of the plant. The cotyeldon has sugar in it for the embryo. Air, sun and water mix together. Photosynthesis is like when they're mixing together. I: To make? M: Food for the plant. I: You don't have animals on here. They're not related? M: I don't think so. I don't think so, 'cuz they can just eat food. I: Explain these stickies that you added M: Scientists do experiments to see if fertilizer, minerals, soil and dirt are food for plants. I: What did they decide? M: I dunno, that it wasn't, it just helps it grow, the roots to grow.	M: Beans. It was fun doing experiments. The bean grew, a whole bean by itself will grow. It starts out as a little bean sprout. I: Where does the sprout get food? M: Sugar in the cotyledon. I: Does it always get food from the cotyledon? M: No, after the cotyledon falls off, it got food from the dirt and the water. They, we never did figure out how it gets food from the soil, did we? I: Tell me more. M: We were talking about, "How does the plant get food from soil?" and I thought it was those little foamy things in the soil . . . I: What about water? M: Water, sun and air make food for the cotyledon. I: How? M: Its mixed together in the leaves, then it worked its way down.. I: I'm confused. Does it get food from dirt or water? M: [Shakes head] I changed my mind. The dirt isn't anything for the food, it just provides areas for the plant to sit on. The foamy things help sorta but not a lot.

Table 4 cont'd

MICHELLE (M) (cont'd)				I: Does this banana plant have anything to do with science? M: That's a strange question! Sun, air, and water could be going through the leaves and feeding it--it could be like the bean plant. I: Can you explain that? M: Maybe sun, air, and water is going through the leaves and feeding the banana part. It made photosynthesis with sun, air, and water mixing together to make food. It comes down and feeds the banana part, down to roots and feeds the rest.

Table 4 cont'd

HEIDI (H)	The kind of food that you can get with plants and flowers that desolves in the water and goes right into the roots all the way to the top of the plant	water, air, and sun they mix that and it makes food to store and eat	H: Photosynthesis is the way the plant makes food. The plant mixes water, air, and sun and then it makes sugar. Scientists study food for plants and then animals and plants have cells. The leaf stores energy and it goes from the leaves to the stem to the roots. The seed or the cotyledon grows a baby plant, or an embryo. Chlorophyll is green. Fertilizers and minerals don't have energy; fruits and vegetables do have energy. Tubes are in the plant for sun and air to go into them. I: How does the leaf store energy? H: The leaf gets its energy from the water, the air, and the sun and then it mixes it together and then it stores it in the leaf and then it goes to the stem and then goes down to the roots and stores food in the roots so the roots can grow and so can the plant. I: What about the seed? H: The seed and the cotyledon grows an embryo (or it's called a baby plant). It gets the sugar from the cotyledon and then when it pops out, it gets water, sun and air and it makes food. I: In the leaves? H: Yeah. And then it goes to the stems. I: How does food get into the seed? H: From the mama plant.	H: Photosynthesis. I: What is photosynthesis? H: How the plants get their food. I: Tell me about that . H: After the plant, it it's under soil, after it gets over the soil, and gets its own food, and the cotyledon is gone, the sun gives it some of its food, then the air gives it some its food, and then if you water it, that's some of its food, and they all mix together in the leaf, and it passes it around the plant to keep it going and some places they store food and then it goes all the way down to the roots, to give the roots energy to grow. I: Why do they have to send it to the roots? H: So the roots can grow bigger and then the plant can grow bigger. I: Can the roots make food like the leaf can? H: No, because they're underground, they can't get the sun and the air underground. I: Are you saying that there are three kinds of food? H: No, there are three things that the plant needs, and they mix together to make food or energy for the plant. I: Can you say more about the cotyledon?

Table 4 cont'd

HEIDI (H) (cont'd)				H: When the cotyledon didn't have any embryo and then the embryo grows out of it, the embryo would get the food from the cotyledon, 'cause there's sugar inside the cotyledon. As it gets older, the cotyledons goes so there's less and less sugar in it, and it goes on top of the dirt, the cotyeldon just wears away and then they use the sun, the water, and the air for food.

Table 4 cont'd

MATT (M)	I think food for plant's is water, sun light, soil, fertilizer.	it's sun, water and air mixed together in the leave by photosynsis	M: Scientists know that the embryo in the seed uses sugar in the cotyledon to grow. Scientists know that plants have cells in their stems and in their roots and the food travels through tubes that are in the stems. I: Where does the food go to? M: The cells. Scientists know that plants use photosynthesis to create food by mixing sun, air and water in the leaf. And they also know that there's a chemical in the leaf that's called chlorophyll. It helps it make food, it makes the leaf green. Fertilizer and minerals don't have energy. I: How do you think scientists figured that out? M: By looking into the plants with really strong microscopes and really studying for a long time and doing all sorts of tests and models. I: Did we do any convincing tests or models in class? M: Um-hmm. The bean seed experiemnt. The embryo can't grow without the cotyledon cuz the cotyledon gives the embryo food.	M: I'd say the best thing was plants. I: OK, tell me about that. M: I think it's plants because we spent the most time on it, and we did a lot more collaborating than we did in dinosaurs, and humans, and sound. . . . I'm not saying we didn't collaborate, but in plants it was kind of new and we didn't know anything about it. I: So you feel like you learned more? M: Uh huh. I: What did you think about plants before? M: They were just something that cleaned the air. First there is a seed that has a cotyledon and an embryo in it. The embryo feeds the plant, like there are desert plants and stuff. I: Explain that to me. M: The embryo has some sugar inside of it, that's what the plant eats because it doesn't have any leaves yet, so it can't make its food. Once the plant gets leaves it mixes air, water, air, and sunlight to make sugar--its food--which is made in the leaf and gives it energy so it can make fruits and vegetables.

Table 4 cont'd

LATICIA (L)	Water and sand. Because the water helps it grow, and to make you grow you have to eat it.	Food for plants is water, air, and sunlight. All of that mixes together and make food for plants.	L: Photosynthesis is what this group is called: air, sun, and water together is food for plants. Sugar by itself is food for plants. The cotyledon is food for plants. It gives energy for the plant. I: What does air, sun, and water form? L: Food for plants. This group is scientists. Scientists ask questions, and they give evidence. This group is about storing food for plants: The leaf it has chlorophyll in it. The leaf stores food, the tubes, the roots. I: All store food? L: Yup. I: What is the importance of chlorophyll? L: It makes the leaves turn green. When there is sunlight, that is the only time it can do it, only when it is in the light. Animals, fertilizer, and minerals are not food for plants. Fruits and vegetables makes a plant and a seed makes a plant and an embryo makes a plant.	L: Food for plants! I: What is food for plants? L: Water, sun, and air mixed together makes food for plants. I How do they mix? L: In the leaves. The water goes in the soil through the roots and goes up and the sunlight goes through the leaves in the holes, and the air does too I: Anything else you can tell me? L: It travels, that's the part I didn't get quite to understand, how where did it go? I thought it goes all through the plant and stuff. I: How would it get all through the plant? L: Travel through the tubes. I: What was confusing about that? L: I didn't understand at first, where all the food went. I: Where does food get used by a plant? Why does it need to travel? L: To feed other parts so it could grow—the roots, a flower.

Table 4 cont'd

LATICIA (L) (cont'd)			I: What do you mean "makes a plant"? L. It turns into a plant. A vegetable is an onion, right? It could turn into another onion plant. It comes through, because I have one at home, It grows green things out of it I just know they can do that. I: Is there some special structure they have that allows them to grow? L: Yeah, inside of 'em, in seeds they have an embryo.	I: Tell me more about the cotyledon. L: The cotyledon is the part, if you are a bean, you have to eat the cotyledon, it does down until you're a grown-up plant; then it can start feeding itself.

Table 4 cont'd

RUSSELL (R)	liquides, powdery stuff	photosynthesis, cotyledon	R: Well, the embryo and the cotyledon start out as a seed. And for photosynthesis there's sun, air, water. (instead of sun they should put light). Energy is sugar. They can use fertilizers and minerals for something but it's not food. And then it turns into food. I: What turns into food? R: Photosynthesis. I: What makes the food? R: The leaf. I: How? R: Photosynthesis. The light, air, and water. It goes into the leaf, and mixes it up; then it goes to the stem and through the tubes to the roots. Then it makes fruits and vegetables or just plants. Then the animals or scientists (people) eat them. I: Can you explain that . . . R: The leaves make photosynthesis. Then it goes through the stem, in the tubes of the stem, into the roots. I: What's going into the roots? R: The photosynthesis. I: What is photosynthesis? R: The food, then it gets stored there. When it needs it, it makes fruits and vegetables.	

Table 5
Students' Pre- and Posttest Responses to Two Application Questions

Pretest and Posttest Question:
A man wanted to have an early garden. He planted some tomato seeds in boxes. He kept the boxes in a closet where it was warm and dark. He watered them whenever the soil started to get dry. There was plenty of air in the closet. What do you think happened to the seed? Why would this happen?

STUDENT	PRETEST	POSTTEST
Nan	They did not live becous the man did not give hem no withe [water] or lite	They did not gorw becous they did not have enig air wather or sun for for it to stay alieve. Then again it mint [might] not of neen [needed] air water or sun. They have to have air, water, and sun for food.
Tiffany	died It got no ligth	it gorwn but it is yellow. Becase it had no light for food. It wounld grown but it will be yellow.
Nathan	it won't grow as much but it well live because it need light to grow more qucer	It will grow a little but they will die when the leavs turn green because it needs to get sun to help mix them together. Because it needs to get air, water, and sun to help it helthey, to grow and make food
Roberto	no bkes thaey donte have sunlite.	Thay would grow a lit [little] and diy. [Dictated to teacher: They would grow from food from the cotyledon they would later die because of no more food from the cotyledon and no sun to make food]
Michelle	I think they would die the wouldn't get eneyorgy from the light or sun	it would die because it didn't have any light energy

Table 5 cont'd.

Heidi	They died because he did give them water but plants need the suns energy to grow. Because he did not give them light and the need the suns energy to grow.	they started to grow but then died Because when it is a baby it uses the water and makes sugar in the coydeledon but when the coytledon is gone it does not have sugar to eat so it needs sun, water, and air to mix and make food
Matt	They didn't grow very well. because it didn't have sunlight.	they grew from getting sugar out of the cotyledon but it ran out of food and couldn't get any food so died. because it needed to have light energy to mix with water and air
Laticia	they didn't didn't gorw Because it needed light for energy	I know that it grew and it died when it ate the coledons and it was no more food for the plant. Because when plants eats the coledons it doesn't have anymore food. It needs three things to make food and the are: water, air, and sunlight.
Russell	they didn't gorw they needed food and sun light	they probly grew but then died. The seeds also needed light [for photosynthesis]. The plant had the cotyledon [to start to grow]

Table 5 cont'd.

Posttest Only

A box was placed over the top of a plant so that all of the plant was covered except one leaf. The plant was watered and had plenty of air, but only that one leaf could get sunlight. What do you predict will happen? Why?

STUDENT	POSTTEST
Nan	The one life [leaf] will live Becous that life gets air water sun The rast get air but not sun and water[The one leaf] will make food and it will have food
Tiffany	That laves [leaf] will live. Becase it got light for food.
Nathan	I think it will live because it only needs one leave needs to make food but if the roots don't get waterd it wont grow
Roberto	[Dictated to teacher: the plant will grow because it gets enough air and water and just one leaf gets sunlight so it will grow. The one leaf mixes it and it stirs it until it turns into a sugar and then it comes down and stores it for later.]
Michelle	it will grow then die because the whole plant won't get sun light for making food.
Heidi	I think it will grow. because it has all it needs to mix food and it can send it anywhere
Matt	it cant make enough food because just that one leaf can't feed every single cell
Laticia	It will live Because it has all three of the things to makes food. It needs water, air, and sunlight [together] to make the plant grow.
Russell	it would grow better than the ones in the dark. because it got light. The only food they could get [in the dark] is the cotyledon.

These results are especially striking for me because of earlier studies in which I found fifth graders exploring these same concepts in a hands-on curriculum (Science Curriculum Improvement Study) but ending the unit holding the same ideas that they held at the beginning of the unit about how plants get their food. On a very similar posttest, only 11% of the students in that earlier study ended the unit holding the central understanding that plants get their food by making it, not from taking it in through the soil or water. They started the unit holding beliefs about multiple and external sources of food for plants, and they ended the unit holding these same beliefs. These students were frustrated by "all that measuring and graphing," and didn't understand the point of it all. If all the work did not lead them to any new understandings, is it so surprising that the activities of science remain mysterious to these students? In contrast, the satisfaction of students like Nan and Nathan in coming to really understand how plants get their food played a critical role in changing their attitude toward learning science.

Particularly impressive in our data on the students' learning are the students' explanations of their understandings about plants six months later, in an in-depth interview at the end of the school year. Remember that the students represented in this data include many who are considered "at risk:" Roberto, who had always been in a special education pull-out program until this year; Nan, who was pulled out of science frequently for speech therapy and reading support; Tiffany, who had repeated a grade and received Chapter 1 resource room reading support; Laticia, who was the only Black student in the classroom and who faced many social struggles in becoming accepted in this classroom; Russell, who struggled with emotional problems and a difficult home situation. The group of students also includes two--Nathan and Michelle--who had learned to become almost invisible in traditional classrooms as a strategy for hiding academic weaknesses and for not sticking out as needing extra support. Matt and Heidi represent the students who are verbal and academically successful in traditional classrooms. And these "stronger" students did not seem to suffer because of the teaching approach. Like their peers, their ideas underwent significant change, and they perceived themselves to have "learned a lot:"

KR: How long should teachers teach a topic?

Heidi: On the plants, I think we learned a whole lot about that. It depends on how much there is to know about it. I didn't know how plants made their food, I didn't even think about that. And then I learned how their food was made, and where it went to, and how it grew and that took maybe a month. And I really liked that. I like studying a long time about a thing if there's enough to learn about it.

*****

KR: Was there something we studied in science this year that you really felt like you understood well?

Matt: Plants, I think. Because we spent the most time on it. We did a lot more collaborating than we did in the dinosaurs or humans . . . and plants is kinda new and we didn't know anything about it.

KR: You feel like you learned a lot?

Matt: Um-hmm.

KR: What did you think about plants before?

Matt: They were just something that cleaned the air.

KR: Did you have any idea how they did that?

Matt: No.

KR: Do you have any ideas now about that?

Matt: They give off gases and stuff . . . when they suck in the air, they clean it and the gases come out and it replaces the air.

Thus, the most academically strong students in the class were not impatient with what some might complain is a slow pace of "coverage of content." Like the rest of the class, they felt like they learned a lot about plants. Table 6 compares pre- and posttest conception scores for the entire class of students, showing that all students started the unit with misconceptions about plants and their food (negative conception scores) and that all students made significant growth in coming to

Table 6
Conception Scoring of Food for Plants
Pre- and Posttests
Fall 1990

STUDENT	TEST	II2	II4	II6	II8	III1	III5	IV2	V1	Total PRE	Total POST	GAIN
Allison	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	1	2	4	3	1	3	2		19	+25
Julia	Pre	- 1	- 1	- 1	0	- 1	1	- 1	-	- 4		
	Post	4	3	2	4	3	2	3	2		23	+27
Keri	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	3	2	4	0	1	2	1		16	+22
Nan	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	2	2	3	1	0	2	2		15	+21
Matt	Pre	- 1	- 1	3	0	- 1	- 1	- 1	-	- 2		
	Post	4	3	2	4	3	1	2	2		21	+23
Nathan	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	3	3	3	3	1	1	1		18	+24
Lucas	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	2	2	3	1	1	3	2		17	+23
Heidi	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	3	2	4	4	2	3	2		23	+29
Tiffany	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	4	2	2	2	3	1	4	1		19	+25
Justin	Pre	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	3	3	3	3	3	1	2		21	+27
Jesse	Pre	- 1	- 1	1	0	- 1	1	- 1	-	- 2		
	Post	2	3	2	3	3	1	3	1		18	+20

Table 6 (cont.)

Russell	**Pre**	- 1	- 1	1	0	- 1	- 1	- 1	-	- 4		
	Post	4	3	2	0	3	3	4	1		20	+24
John	**Pre**	- 1	- 1	- 1	-	- 1	- 1	- 1	-	- 6		
	Post	4	3	2	3	3	1	1	2		19	+25
Maria	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	2	- 1	- 1	0	3	1	2	1		7	+13
Kelly	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	1	1	3	3	1	1	2		15	+21
Laticia	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	3	0 ?	3	2	1	2	1		15	+21
Sarah	**Pre**	- 1	- 1	- 1	0	- 1	0	- 1	-	- 5		
	Post	4	3	3	4	3	3	4	2		26	+31
Mike	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 21	-	- 6		
	Post	3	2	1	- 1	3	1	2	2		13	+19
Roberto	**Pre**	- 1	- 1	- 1	0	1	- 1	- 1	-	- 4		
	Post	2	2	1	3	3	1	4	0		16	+20
Michelle	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	3	- 1	- 1	2	3	1	3	1		11	+17
Antonio	**Pre**	- 1	- 1	- 1	0	- 1	- 1	- 1	-	- 6		
	Post	4	- 1	1	4	1	1	2	2		14	+20

understand scientific conceptions about food for plants. (Figure 2 shows the analysis scheme used to construct these concentration scores.)

But more important than their understanding of photosynthesis, was the students' new-found understanding of what it means to understand in science and their self-confidence that they were capable of "understanding" science:

KR: How about during the Food for Plants unit? How comfortable did you feel?

Nathan: Very comfortable. 'Cause see I had ideas as well as everyone else, and some kids would have some ideas and I'd say something else, and some other kids would agree with me and stuff but some wouldn't, and that sorta made me feel comfortable and some kids were agreeing with me and that made me feel really good.

*****

Nan: I felt very comfortable. I understood it, I was happy, I got to answer questions, I knew how to answer the questions.

*****

Nathan: Mark would always say stuff and I'd try to answer his question for him, and he thought I was really good.

Nathan: Well, I wasn't good at photosynthesis cause I didn't know the meaning of it at the beginning. But during the middle, now that I know about it I like learning about it and teaching it to other kids about it. And I like going home and doing experiments and stuff.

*****

Matt: I felt pretty comfortable cause we would write in science journals, and we got to do some experiments and I thought that was pretty fun. I guess I was in between because I didn't know anything about plants when I started.

KR: Did that make you feel uncomfortable?

Matt: Well, when we started it did. But once we got into it a little bit more . . .

KR: Did it make you feel uncomfortable if your ideas were not ones that everyone agreed on?

Matt: No, it would be kind of neat that you thought differently than everybody else.

*****

KR: Where would you put yourself on this line showing how you love or hate science?

Nan: [Before] I hated it. It was not fun. All's we did was talk about stars, we didn't talk about the fun stuff like plants. [Before] I thought I was bad at it. I *love* it now.

KR: Was anything else hard for you to understand?

Nan: I understood most of the plants about photosynthesis. But at the beginning I didn't understand it, in the middle I sort of understood it, at the end I absolutely understood it, but it was hard during the beginning.

*****

KR: Is there anyone in your class who you would say is really good at science?

Nathan: (pause for about 10 seconds) Well, *all* of them are really good, cause they contribute ideas and they answer each other's questions . . .

*****

KR: How long should a teacher stay on one topic?

Justin: I think until everybody understands it real well. So they won't wonder so much--but you do want to let them wonder still.

KR: Not make it seem like everything is all answered?

Justin: Yeah.

KR: Why?

Justin: To see if they can find it out by themselves.

KR: Did we study plants too long, just right, or too short?

Justin: I think we could do it a little longer. I would have like to done to see if you can find the chlorophyll under a microscope or something, in the leaf.

*****

KR: How long should a teacher stay on one topic?

Tiffany: Probably teach until they understand it all the way and you don't have any questions left about it.

KR: Did we study plants too long?

Tiffany: It was just right. 'Cause we learned everything. Like we learned how a bean seed grows, and we learned about photosynthesis and we learned

Food for Plants Conceptions Test Coding Scheme
Fall, 1990 Version

II. 2. Describe what food is for plants.

Cotyledon and making food only	4
Food = air, water, sun mixed	3
Food is made only; photosyn only	3
Sugar only; Air water, sun only (no mention of mixing); cotyl. only	2
Don't know	0
Food made but also other sources listed	-1
Other - soil, fertilizer, air, water, plant food, etc.	-2

II. 4. A man wanted to have an early garden. He planted some tomato seeds in small boxes. He kept the boxes in a closet where it was warm and dark. We watered them whenever the soil started to get dry. There was plenty of air in the closet. What do you think happened to the seeds? Why would this happen?

Started to grow and died; first got food from cotyedon --> then photosynthesis	3
Died - needs sun to make food	2
Died - needs sun, water, air - all 3	1
Other	0
Died - needs sun to grow, there was no light	-1

II. 6. Draw arrows to show how food moves through a green plant. Explain why it needs to travel this way.

Arrows from leaf to rest of plant; to make food and get it to rest of plant.	3
Arrows from leaf to rest of plant; to feed cells; to get food, energy to rest of plant	2
Arrows from leaf to rest of plant; no reason or reason only states to grow or to live	1
Arrow from soil upward to leaves	-1

Figure 2. Analysis scheme used to construct students' conception scores on pre- and posttests.

II. 8. A box was placed over the top of a plant so that all of the plant was covered except one leaf. The plant was watered and had plenty of air, but only that one leaf could get any sunlight. What do you predict will happen? Why?

Will live - one leaf makes food and sends to rest of plant	4
Won't grow - can't make enough for whole plant	4
One leaf will live, rest will die because it has air water and light to make food	4
Won't grow - can't make enough for whole plant	3
Will die - not enough sun to make food	3
One leaf will live, rest will die because it has air, water, light, or it has all the ingredients it needs	3
Will grow - one leaf got food	2
Will grow - has sunlight	0
Won't grow - not enough sun	-1

III. 1. Most plants get food (you may circle more than one if needed)

a. from soil.
b. from air.
c. from water.
d. by making it themselves.
e. I don't know.

d only	3
d, b, c	2
b, c	1
e	0
a, any combination that includes a	-1

III. 5. For plants food means

a. water.
b. water, soil, air, and light.
c. water, air, and light.
d. Fertilizer and minerals in the soil.
e. something plants make.
f. I don't know.

e or e and c with added explanation	3
c & e	2
c only	1
b, d	-1

Figure 2 cont'd

IV. 2. Circle anything that you think is food for plants:

soil
warmth
water
air
fertilizer
cotyledon or seed
plant food you buy at the store
something plants make in leaves
sunlight
proper care

Cotyledon or seed and something plant makes; or adds word photosynthesis (and not cotyl)	4
Cotyledon or seed and air, water, sun; or air, water, sun and make	3
Air, water, sun only;	2
Cotyledon only	1
soil; fertilizer; plant food; warmth	-1

Any combination that includes any of the follwoing:

V. 1. Have you ever heard of the word photosynthesis? If yes, tell what it means as best you can.

Make food in leaves	2
It is food; or sun mixing together with air, water; or has to do with food; or photo - light syn - put together	1
Don't know	0

Figure 2 cont'd

about what chlorophyll is and what it means. We learned a lot about how the plant works.

KR: Didn't you get sick of it?

Tiffany: Not really. It's interesting to learn how the plant works, and what chlorophyll is and how it mixes together, cause I never knew...I always thought the plant just drunk water.

KR: So you changed your ideas?

Tiffany: Yeah. We learned about sugar too and how starch changes to sugar or sugar changes to starch.

*****

KR: Who did you write this journal entry for?

Michelle: My science teacher, the regular teachers, even for Van Helmont if he reads them!

KR: How would that be helpful for science teachers?

Michelle: She would be getting our ideas, and they wouldn't have only their own ideas. They'd have out ideas, too, to work into their ideas.

KR: If we had a visitor, how would you feel about showing them this journal entry?

Michelle: I don't know cause you're just giving them your ideas . . .

KR: How would that feel?

Michelle: Good, cause you know that they'll listen to you, they understand you.

KR: Why did you read what I wrote back to you?

Michelle: It was neat hearing how you thought we wrote, how you thought our ideas were, like if they really helped you understand.

In the process of learning about plants, these students also developed some powerful understandings about the nature of science and the role of discourse and writing in science:

About the nature of science . . .

KR: What kinds of things do scientists do?

Justin: They think a little bit, and they try to see things that other people wonder about, and if they find something real fascinating, they'll try it, and they'll explore their ideas.

KR: What do they wonder about?

Justin: Like how does something make chlorophyll and how does photosynthesis start and when was the exact date that plants came and how many desert animals are there and how kids behave and how kids react to science.

KR: What would you say science is all about?

Justin: Science is a lot of learning and fascinating and wondering.

*****

KR: Why is it important for people to do science?

Michelle: To find out different things so they aren't going with just one point of view. Like when we did the bean plant we weren't just looking at the book.

KR: Why is it important not to go with just one point of view?

Michelle: 'Cause you'd be getting your own ideas, too, like when we were reading books on plants, we weren't just going by that perspective, we were going by our perspectives, too, like doing different experiments with beans.

*****

KR: What makes someone really good at science?

Lucas: Be really patient, do what they have to do, if the don't they won't be good. With me, I'm patient . . . I give my ideas, listen to the teacher, get better ideas and write them in my journal.

*****

Nan: You know, I don't know why I'm bringing this up, but in science, I always used to ask "How do you know? What's your evidence?"

*****

Heidi: I felt like a scientist when we did the bean experiments. Because *we* were finding the things out, we were the ones that were making the experiments. Some people would stay in for recess and make up their own experiments and watch 'em and see how they do. And sometimes we jotted down what we saw, what we found out, and we worked in groups about what we found out.

*****

KR: What else can you tell me about what scientists do?

Nathan: They have to research stuff. . . . They have to look at different scientists' perspectives and see what they think, and then they try and see if they thought it was any different. And then they maybe could try and find that other scientist and talk about it, and see if he thought it was a good idea.

KR: Tell me about this, "they look at other scientists' perspectives."

Nathan: Well, if they were in a book and stuff they might read it, and get some ideas and they might say, "Well, I don't think this is right," and try and change their idea.

*****

Matt: They talk with other scientists to mix their ideas, collaborate to see if they can solve a problem. A lot of scientists don't just work by theirselves, they collaborate with other scientists, and come up with better ideas.

*****

KR: Would it be easy or hard for a scientist to study about humans who lived a million years ago?

Nan: It would be hard because they got to find a lot of evidence, and they got to find a lot of things. They have to find a whole bunch of ev . . . things.

*****

KR: What did you like about doing your own experiment as compared to the class experiment?

Michelle: It was just your ideas . . . you could talk to somebody else about your ideas bout what happened [in the whole class experiment] and it was sorta neat because nobody had thought of that idea. Everybody said "Oh neat, Michelle."

*****

KR: Why would a person want to be a scientist?

Laticia: To find out things for themselves, to know if it's true or not.

*****

KR: Does this journal entry show anything about you as a scientist?

Tiffany: That I've used other people's ideas to change mine and make them better.

*****

KR: Does this writing [points to a November entry in journal] tell anything about you as a scientist?

Heidi: Yeah that I, that scientists change their ideas, and I changed my idea, and I wrote things down about it and we saw an experiment and it turned out that I was wrong, which is OK.

About scientific discourse . . .

Tiffany: Arguments help because you can change your ideas, people help you see it different and it might be better.

*****

KR: What kinds of talking do scientists do?

Heidi: They have arguments sometimes. They talk to each other at meetings about what they found out and how they got that information.

KR: Say more about arguments?

Heidi: Some people might believe one thing, some people might believe in the other, like if I said the seeds could grow in the dark, and the other people might say they can't grow in the dark cause they don't have any sunlight, and that's a part of food and so you do an experiment and find out. They can argue about which one they think is right and then they can try or find out which one is right.

*****

Nathan: When we were in groups we talked about ideas of what we thought, like a question you asked us. And then we got together and had a scientific argument and then we, someone thought it was one idea and someone thought it was another and it just kept going.

KR: And was that helpful to you?

Nathan: Yeah, you got to see other people's ideas and what they thought.

KR: Do you think it is important to know what other students are thinking?

Nathan: Yeah, because it gives you more perspectives. I always say that word, but it does.

*****

KR: What is a good scientific discussion?

Lucas: We got in a scientific discussion about what food for plants is. It's when you're talking about your ideas and other people are talking about theirs and you mix ideas and write them down. You make a different way of saying things that you said.

KR: What if you disagree?

Lucas: You exchange ideas and get agreement. You get ideas from each other.

KR: Is it a bad thing to have a scientific argument or disagreement?

Lucas: No!

*****

KR: Was there anything I said or did in science class that helped you understand how to have a scientific discussion?

Tiffany: You said your point back and then when people were saying their idea, someone would write . . . like say there were two people and each one thought their idea was right, you showed them to combine them like take the beginning of somebody's and the end of somebody's cause maybe they're halfway right.

*****

KR: Do you remember writing this journal entry [from November entry about whether soil is food for plants]

Michelle: That was sorta weird cause we were writing down ideas, but then we were talking to each other and everybody's ideas . . . it got me really confused with everybody's ideas going around the room.

KR: What would you think when it got confusing?

Michelle: I'd get frustrated in a way but then I'd keep trying to figure out, "What in the world is he saying? What does he mean?" I tried to get ideas from everybody else but sometimes they had the same ideas, but everybody had different ideas, too, and that was really confusing. They were all good ideas.

About writing in science . . .

KR: If you had to choose between getting a grade and little questions or comments in your journal from the teacher, what would you choose?

Nathan: Questions. Cause they're more helpful they get you thinking more and stuff . . . if you write to us and ask us questions that gets us writing harder cause we have to answer your questions.

*****

KR: How would you feel about showing this page of your journal to a visitor to our classroom?

Tiffany: They could see how their ideas [other students] have changed my ideas.

KR: What do you think about teachers writing back to you in your journal?

Tiffany: It's helpful because you can understand how you improve what you're saying. Like if you say "explain why you thought that" then from now on, you'd know to explain why you got that idea.

*****

Heidi: I forgot [to put on my list of things that helped me learn] one very important thing to put on this list--journals.

KR: Why were journals important?

Heidi: It's important, because we wrote in our journals a lot and we wrote down what we thought in the journals. And sometimes you'd answer us on what we thought and like put, "Why did you think that?" Then we'd explain or we'd voted or remember what we thought then and look back and see what we knew. Like on the pretest--I remember when I looked back I laughed so hard. I was so surprised after I knew all about it.

KR: So your ideas really changed?

Heidi: Yeah.

KR: Who were you doing this journal writing for?

Heidi: Myself, to look back at and to see what I thought.

*****

KR: Do you see yourself ever becoming a scientist someday?

Laticia: No, I couldn't imagine myself becoming a scientist. I'm looking forward to being a poet or a writer.

KR: Is that something you've always wanted to do? When did you decide to be a writer?

Laticia: I'm writing books now [explains her books]. I might write about science because I loved the part when we had food for plants. So I think I might write a book about that . . . [elaborates on her book idea about "Beanhead" and photosynthesis]

KR: Is there something in science you felt you understood really well?

Laticia: Food for plants.

I remain curious about what might happen if a science teacher took a more open, writers' workshop type of approach in which students decided on topics and forms of investigation. But given the power of these fifth graders' understandings of science. I am reluctant to abandon an instructional structure that enables me as teacher to trace and help shape each students' thinking. If I had 25 students choosing their science topics and exploring them with only process support from me in conferences, would the students be able to come to know what it means to really understand something in a scientific way? Would they experience the satisfaction of changing their incoming beliefs as their ideas were challenged by emerging evidence and alternative explanations? Would they develop an appreciation of important features of scientific inquiry such as collaboration, the tentative nature of knowledge, the importance of open-mindedness and willingness to change, the role of evidence in the construction of scientific explanations? It was challenging enough trying to trace and shape 25 students' thinking on a common topic; would it be feasible to do this with students working on different topics?

As I continue to teach science to fifth graders, I find myself influenced significantly by my observations of writers' workshop. Although I continue to focus science explorations around problems shared by the class, I am more sensitive to finding ways to support students also in exploring their own questions. Each year I find myself building more time and support for such endeavors into the science curriculum. But I am reluctant to move toward a curriculum totally centered around students' choices for topics because of the quality and depth of understandings I saw Nan, Tiffany, Russell, Nathan, Michelle, and their classmates develop in a curriculum structured around group problems and consensus building.

Discussion Across the Cases

The study provides insights about the ways in which instruction across subject matters can be integrated and coherent (see Tables 1 and 2) without simply asserting that teaching is a generic activity--that there is one instructional framework that will work for any subject area. Although it would be reassuring to have a generic model for teaching about writing across the curriculum (especially for elementary teachers who are responsible for teaching all subjects), our study suggests that there are ways in which teaching writing and teaching science are distinctive activities with distinctive instructional goals that require different approaches and different teacher roles. The two instructional models described in this paper provide different images of how teachers can create classrooms where both high student and high teacher input are possible (Calkins, 1986). They are two distinct images of how teachers can think carefully about the unique kinds of teacher input that are needed in relation to distinct subject matter goals and how writing plays a role in students' learning.

Contrasts in Subject Matter Goals and the Functions of Writing

In science, Roth's main instructional goals were to support students in learning science concepts using a conceptual change model as a guide. The writing assignments were used as a tool to get students to share, try out, examine, contrast, and revise ideas. Students were expected to wonder and ask questions on paper. Written products were a "still image" of ideas to be preserved and examined at a later date. Writing primarily served two of three writing functions described by Britton et al. (1985). For example, writing was often done for the writer's own use (explore one's own ideas) and for a limited audience (sometimes oneself or a small group)--an expressive function. Writing was also used to get things done--a transactional use. Using writing for a poetic function (using language as an art medium) was not emphasized, as it was in the writers' workshop model.

Writing in science was used to extend and support the overall inquiry process regarding the nature of science and science concepts. It was an integral part of a series of activities that were all focused on supporting the conceptual change process, in such a way that the talk surrounding the writing was as important as the writing itself. Writing activities did not consist of a collection of "neat assignments" plugged into a science unit; instead they were an integral part of the inquiry process. The writing emphasized the tentative nature of ideas, the need for re-examination and revision of ideas. By having all students write about the same topic, the learning community could share and debate the ideas students were writing about, and Roth could support the examination and debate. Science learning goals determined the topic, audience, form, purpose, main idea, anticipated audience response, and talk surrounding the writing. Response to the writing centered primarily on ideas within each piece, rather than on form, text conventions, or overall reaction to a piece as would be emphasized in a writers' workshop.

Instructional goals in a writers' workshop include teaching students to write for all three purposes (expressive, transactional, and poetic) and tend to focus on helping students perfect the craft of poetic writing. Given these instructional goals, young writers need the opportunity to practice making judgments about when and how the three kinds of writing will help them realize their intentions as writers. Students are encouraged to share their written texts for the purposes of getting a response from the audience to get feedback regarding their decisions in crafting their piece: chosen topic, form, ideas in the text, text conventions and overall reactions to the piece. Talk surrounding writing emphasizes the tentative nature of written text as a personal and unique expression of ideas, that the chosen form and style of expression are evolving and can be revisited and revised many times. By encouraging students to write about a variety of topics and try out a variety of forms and techniques and share their experiences along the way, others can benefit from the breadth of writing activity. Writing goals determine the range of choice available to students in a writers' workshop.

Contrasts in Subject Matter Goals and the Teacher's Role

Contrasts in the nature of the subject matter to be learned in science and writing may change the requirements for the kind of support teachers need to provide for students as they write in the two contexts. Moreover, when teachers have different aspects of the writing process to support in teaching science and writing, assignments may need to be designed differently.

In a writers' workshop, the subject matter is learning to create texts for particular purposes--learning to manage the many decisions authors make to craft a piece of writing (e.g., topic, audience, form, purpose for writing)--and coming to value writing as a worthwhile activity. Accordingly, teachers need to support students in using writing to develop (a) personal knowledge (of self and one's relationship to others), (b) social knowledge (of others, of contexts in which readers may interpret writing, of audience), and (c) knowledge of language and texts. They also need to help students develop strategic control over making the decisions associated with creating a piece of writing for a particular audience. Therefore it is appropriate and necessary to set up the writing environment in ways that allow students to work with these multiple decisions. Fifth-grade students working within a writers' workshop instructional model had opportunities, with Rosaen's and Lindquist's support, to practice managing the range of decisions authors make and create texts that serve a range of functions (expressive, transactional, poetic).

In science learning, the teacher's main focus in providing support shifts from supporting learning to write to supporting learning science concepts and scientific approaches to inquiry. Roth viewed her role as supporting students in changing and enriching their thinking about science concepts and the nature of science over time--a conceptual change process. Writing is one source of support during the change process. The teacher needs to help the students understand ways in which their thoughts in the writing are the "text" over which they can interact in the learning community--ask questions, clarify, revise, and so on. Therefore, it may be more appropriate for the teacher to play a central role in designing the actual writing topics and tasks so that she can support the thinking process. By setting aside the decisions writers make (e.g., What should I write about? What is my main point? How should I write it? For whom?), students can concentrate on developing better explanations about specific phenomena in the world around them and be guided and supported in examining and revising their thinking through classroom discourse and inquiry. Fifth-grade students had opportunities, supported by Roth, to use different forms of writing as a tool to explore, study, and revise their ideas. If each student had pursued his or her own question or topic, Roth's ability to scaffold student thinking would have been limited.

What Is Being Taught and Learned?

It all sounds fine to advise teachers to set certain aspects of writing a piece aside so students can concentrate on other aspects more specifically. For example, Roth had students focus on expressing ideas while setting aside concern about spelling or grammar. Nevertheless, as students complete any writing tasks in classrooms, they construct a general understanding of what it means to write (Rosaen, 1989, 1990; Scardamalia & Bereiter, 1986). Even if the teacher's instructional goals focus on science, students still will learn something about themselves as writers when they write in science class. Given the characteristics of the science writing tasks described here, what are students likely to learn about writing from these kinds of writing experiences, and do these likely conceptions conflict with what would be considered worthwhile goals for writing instruction? Will these kinds of science writing experiences contribute to helping students become better writers and enjoy writing?

The examples discussed by Roth in this paper indicate that the students would interpret writing in science to include the following:

- Writing is thinking on paper
- Ideas are tentative, even if they are written down
- Writing is a place to ask questions and show what you don't know as well as what you do know

- Different forms of writing can serve different learning goals (e.g., get initial ideas down on paper; revise and change ideas; use ideas to address real-world problems)
- Writing is both private and public
- Writing is part of the learning process
- One's responsibilities and participation in the learning community may shift, depending on the focus of inquiry (writing as subject matter, science as subject matter)

If students had not also had the opportunity and support to experience the full range of authorship decisions in this fifth-grade classroom during writers' workshop, the above list is not complete enough to say that the fifth graders are learning what they need to learn about becoming writers. However, the experiences provided by Roth show students a different side of the writing process--ways to use writing for subject matter learning--that are very difficult to support in a workshop setting where students are all writing on different topics and for different purposes.

Roth's use of writing in her science teaching suggests alternatives to providing students the same array of choices they encounter in a workshop setting: topic, form and time frame. These choices do not seem to be the most critical ones for developing student ownership of the writing and learning process in science and other content area learning. Perhaps there are times when it is beneficial for the teacher to play a central role in designing the actual writing topics and tasks so that she can support aspects of the conceptual change process as they emerge over time. This is a way to show students how writing can support genuine inquiry into real questions and problems. The students still have critical ownership of their own thoughts in carrying out the assigned writing tasks. Over time, students can be helped and encouraged to reflect on ways in which the more structured writing tasks the teacher has assigned in science are useful to them as learners, and thus will be contributing to their own understanding and use of writing as a thinking and learning tool. Roth did build in ways for students to make choices about writing in science as the units progressed. In this way, writing becomes a way for students to listen to themselves as they think about a topic, and the process of living with and learning from their writing also will affect their future writing (Calkins, 1991).

This kind of content area writing also provides an alternative to the typical "writing across the curriculum" advice, where any writing that is done in relation to subject matter learning is considered valuable in and of itself, or where "neat assignments" are plugged into subject matter units or where writing is used only as a way for students to show what they know. By providing carefully thought out assignments that are a natural part of an inquiry process, the writing is purposeful and more likely to support growth in subject matter understanding, instead of just hoping it happens because students wrote.

Realizing the Shared Vision of a Learning-Centered Classroom

The fifth graders in this classroom experienced different kinds of writing activities in the contexts of learning science and learning to write. In the context of learning science, Roth had control over many aspects of the writing process so that student thinking and inquiry could receive greater support. In the context of learning to write, a writers' workshop model provided occasions for students to make many of the decisions that Roth made in science writing. Rosaen's and Lindquist's support focused on helping students learn the craft of writing and come to appreciate writing as a worthwhile activity.

In a typical elementary classroom situation, these different kinds of instructional decisions would be made by the same person instead of by three different teachers. The same teacher would need to reconcile the two perspectives and ask whether they contribute to the overall learning community she has in mind. Similarly, in those settings where instruction is team-taught with different teachers responsible for teaching different subject matter areas to the same students, the team would need to reconcile the two perspectives. To what extent are the two kinds of writing experiences consistent with the shared vision of a learning centered classroom we portrayed earlier (Table 1)? Both types of writing activities are consistent with the qualities of the learning setting we were trying to create.

In both settings, while the focus of the sense making was different (science concepts, learning the writer's craft), sense making and learning were the overall goal. In both contexts, although the nature of the problem situations that were created was different, personal and emotional involvement in addressing the problems was fostered and required ownership, commitment, and shared responsibility by each member of the community. Likewise, active inquiry and question asking (about science concepts, about the writer's craft) were valued and encouraged. In both contexts learning was both public and private, and expertise came from members of the community where everyone's ideas were valued and respected as useful in the learning process. Evidence, not mere authority, was used to judge the merits of ideas or the quality of a piece of writing, and students were "good learners" when they listened and responded to each other. Celebration of the learning process and ideas took place regularly in both contexts. Finally, each learner started and finished in a unique place in the learning process, and diversity among learners was valued and appreciated. As writing served different purposes for the fifth graders, writing experiences were connected as closely as possible to genuine inquiry into what it means to learn science and what it means to become writers.

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